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J. A. BERLY'S

UNIVERSAL ELECTRICAL DIRECTORY

For 1893

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CAPITAL AND LABOUR.

VIEWED whether as from employer or employed, the problem of capital and labour presents similar difficulties; it is an equation involving but one *constant:* the selfishness of the one side as seen by those on the other.

Over-production; cost of living; competitions; uttermost profits; highest wages; extraordinary risks; deductions for losses; Continental prices; professional agitators; strikes; battles; murders; sudden deaths—these are the bagatelles of contention which constitute the *variables* in the living equation. Against them there rises but a single means of effectual solution—the firm determination on each man's part, whether labourer or capitalist, to meet half-way the claims of his opponent.

In a recent pamphlet by Lieut.-Col. Coates, under this heading, he says:—"If ever matters are to go on smoothly, mutual concessions must be made; and in order to do this, the parties now, unfortunately, arrayed against each other, must approach in a conciliatory and candid manner, when doubtless the misunderstandings will soon vanish, and the way will be found for a *modus vivendi* to be arrived at."

Now-a-days, it seems to us, the true cause of distress not so much lies in the tyranny of employers, or the lack of generosity in the employed, as in that "cussedness" of things which constitutes the irony of fate. Indeed, employers, as far as we know them, are mostly jolly good fellows; and, as a rule, we are certain they are very truly sorry for the hardships incurred by their men. On the other hand, we have no particular fault to urge against the *bonâ-fide* work-people; we believe they disfavour strikes as keenly as do their masters, unless by circumstance driven to actual desperation, or by the ravings of that contemptible fanatic, "the professional agitator," led to act with temporary insanity.

Ultimately, the problem of capital and labour must resolve itself into the question of the redistribution of the people. It is the crowding-out which congests our present system. We prefer to view the struggle, not as a battle between men and men, but rather as the united attempt of all men against *things*. The world is big enough, why do we sit so close? It is true that great success has not favoured our latest enterprises in emigration. Those who have set out have been overtaken by illness before their work was fairly under way; many of our countrymen are now abroad in this unhappy plight. Yet we cannot help thinking that their distresses are consequent upon the comparative smallness of their numbers with the difficulties to be overcome; and their poverty even at the start. For success, the scheme must include all that is necessary to healthily open up a country—equipments for drainage, irrigation, food supply. Of what use is it to colonise in eights and tens when there is work for as many hundred thousands. Pessimists prescribe a

good healthy war as being an effectual means of "thinning out" superfluous populations. It may be this is a prompt solution, but it makes a terrible mess. Economists think that "transplanting" is better.

Nevertheless, the very possibility and practicability of organising a war is a demonstration of what can be done by the resolution of forces. We prefer to imagine a twentieth-century campaign, not *vi et armis* against men, but with a determined attempt to make a new country habitable.

For present needs we are bound to face the contention between capital and labour as it stands. Lieut.-Colonel Coates suggests that employers should take their operatives more into their confidence, and more generally identify themselves with them, letting them know when times are slack, and informing them when things are brisker. With this we do not entirely agree, for there are few workmen who would really profit by such a system. Workmen have their own ways of knowing how the coast lies, and they prefer to make their own observations in this respect. They are very happy with a sliding-scale as long as it slides *up*, but they are not the sort of fellows to easily submit as it slides *down*. It needs a particularly organised individual to do that. Lieut.-Col. Coates predicts that education will secure such men, and that then the fatal misunderstandings between capital and labour will assuredly vanish. To us, it is very doubtful whether education will produce workmen resigned to a falling scale, and willing to take the lower wages; the personal element counts for so much, it is the omitted word in this great competition. This is where the difference is felt, by a workman, between a private firm and a public company. In the limit, the employer is an indifferent sort of "money-box," and the workman is a mere "hand."

There is no better arbitrator in the settlement of wages than the employer himself, and there should be no need for him to submit his propositions to his men. If he is a just man, he will give them a fair price, knowing what he can afford; and it is certain that if he is unjust, no value can be forthcoming from so-called "confidences" with his operators.

ELECTRO-DIAGNOSIS.

A preliminary account of Dr. Dawson Turner's research on electro-diagnosis by means of the urine, was laid before the Royal Society, Edinburgh, in December last, and a paper now before us, based upon a more extended series of experiments, is a further contribution to the same subject.

The object of the inquiry was to ascertain the electrical resistances of various kinds of urine both in a state of health and disease. The measurements were made by means of a Wheatstone's bridge with alternating currents and a telephone, according to Kohlrausch's method, and at a temperature of 65° Fahrenheit. The resistance could also be estimated, though less accurately, by the current from a few Daniell cells, a galvanometer, and an application of Ohm's law. The first 70 experiments were made by this method. It would appear from the observations, some 500 in number, that the specific resistance of a normal urine amounts to about 45 ohms, and that it varies as a rule inversely with the specific gravity. The latter is a measure of the amount of solids in solution, and particularly of the urea. It might be supposed, then, that the resistance depends also mainly upon the amount of urea; this, however, is not the case. A number of experiments were made with artificial solutions of urea, sodium chloride, phosphates, sugar, &c., in distilled water, and from these it is clearly apparent that the electrical resistance depends almost wholly upon the salts, chlorides, phosphates, sulphates, &c., and that it is only when these are absent or diminished that the influence of the urea makes itself felt. The resistance is, therefore, a measure of the chemically active substances in urine, of the salts, and to a very much less degree of the inert urea. This gives us a simple and rapid method of estimating the constitution of a urine as regards its salts, while the specific gravity, in the absence of sugar, is a guide to its urea. In a normal urine, these go more or less inversely together; given the specific gravity and the resistance can be estimated, and given the resistance and the specific gravity can be calculated.

In diseased conditions there are certain exceptions to this rule—"That the resistance varies inversely with the specific gravity," which can be arranged accordingly as they occur in acute or chronic diseases. Excluding acute infectious diseases and local surgical affections, the two most prominent exceptions are—amongst the former, acute croupous pneumonia; amongst the latter, diabetes mellitus.

That the urine of a case of pneumonia should offer a higher electrical resistance than would be predicated from its specific gravity is easily understood, when the great diminution of the chlorides in the urine of a case of this disease is remembered; but the increased resistance of a diabetic urine affords a question of a more interesting nature. In this disease the specific gravity of the urine is high, and the electrical resistance offered by it is also high, and sometimes very high. Thus the specific gravity may be considerably above 1,030, and the resistance at the same time as much as 150 ohms, while the resistance of an ordinary urine of a specific gravity of 1,030 would probably be below 40 ohms.

Upon what does this increased resistance depend, to a diminution in the salts, or to the presence of the sugar? Almost wholly to the former. A 1 per cent. solution of sodium chloride has a resistance of 59·5 ohms, and the addition of 10 per cent. of grape sugar only raises the resistance to 68 ohms; a 2 per cent. solution of sodium chloride has a resistance of 29·25 ohms, the addition of 20 per cent. of sugar raises it to 51 ohms, and of 30 per cent. of sugar to 63·75 ohms. With smaller percentages of sugar there may be scarcely any effect.

It cannot, therefore, be doubted that the sugar, probably hindering diffusion by its viscosity, does to a slight extent raise the resistance of a saline solution. (It will lower the resistance of distilled water when by itself.) But by far the greater part of the increased resistance of a diabetic urine is due to the relatively great diminution in the salts, and it is to the credit of the electrical testing that this fact is brought so prominently forward. It will be found further that this resistance usually diminishes with the amount of sugar passed, and that it may be utilised as a test of the patient's progress. Whenever we find a high specific gravity together with a high electrical resistance (above 80 ohms specific resistance), we may suspect the presence of sugar. The specific gravity is raised by the sugar, and the resistance is increased by the diminution of the salts.

In acute and chronic Bright's disease the resistance is high, also usually in chronic bronchitis, phthisis, mitral disease, and anæmia, particularly pernicious anæmia. The effect of diet has to be considered. Copious draughts of water increase the resistance. Taking much salted food diminishes it, &c. The urine passed in the early a.m., if a late dinner or supper is eaten, commonly has a relatively low resistance.

By this means, then, we are enabled to make an immediate rough estimation of the constitution of the urine, and particularly of its salts, chlorides, phosphates, sulphates, &c. —a result which could only otherwise be arrived at by a tedious chemical analysis. The specific gravity of a urine depends (in the absence of sugar) mainly upon the urea; the electrical resistance upon the salts; by combining these we can at once form a fair idea of a urine's constitution, and of the efficiency of the kidneys.

So far as the condition of the urine reflects a patient's condition, one of the best gauges of it is the electrical resistance; and more than that, even in other conditions, when the kidneys were supposed to be quite unaffected, as in the case of pernicious anæmia, the electrical resistance will usually closely follow any changes in the patient's condition, changes sometimes of so slight a nature that they would otherwise almost escape notice. The urine to be examined should be fresh, and should be a specimen taken from the whole amount passed in the 24 hours. The resistance diminishes as the urine is kept from fermentation changes. This method of examining the urine is completely in its infancy, and much may be expected from its further development. Not that it is intended that it will in any way replace the ordinary methods of examination; it is an adjunct to them, and one apparently of much promise, that can be very rapidly carried out, but whose precise value has yet to be determined.'

Whatever this may prove to be, Dr. Dawson Turner deserves the warmest thanks of the medical profession for introducing electro-diagnosis in the manner shown, and we may hope that the day is not very far distant when diabetes and kindred complaints may perhaps be treated electrolytically as a means of diminishing the excess of sugar and albumen developed by sufferers from these distressing and generally incurable complaints.

THE TELEPHONE COMPANIES.

It may reasonably be assumed that the present stage of the company's existence is not its last. The difficulties of its position will probably be found to be capable of being simplified by a more complete amalgamation.—*Electrical Review*, August 5th.

We are able to announce that the New and National Telephone Companies yesterday arrived at a *modus vivendi*, more intimate and, from a public point of view, far more satisfactory than the policy of partial amalgamation which has hitherto regulated their mutual relations.—*The Standard*, December 10th.

THE New Telephone Company is now an organisation of such importance, that the *Standard* accords to it a position of priority to which it is not entitled by its deeds, its age, or the alphabet. The late Duke of Marlborough took so active a part in telephonic agitation, that the *Standard* is convinced "the British telephone system is deeply indebted to his laborious efforts."

From his permanent seat in the Legislature, and his temporary seat in the Chamber of Commerce, the late Duke spoke on telephones. In the columns of the *Times*, and the pages of magazines, the late Duke wrote on telephones. In all, the burden of his song was that the telephone system needed competition, that competition would lead to public benefit, and a new competing company would pay a higher dividend on a smaller capital, whilst charging very much lower rentals. Remembering these facts, it becomes difficult to realise, as the *Standard* informs us, that the late Duke was engaged up to the very time of his death in the "negotiations which have now been brought to a successful completion."

By the adroit use of shibboleths, a public opinion in the *bonâ fides* of the New Company was undoubtedly created. By tacking on to their proposals such technical features as metallic circuits, translated for public benefit into "twin wires," they are now able to offer as their contribution to the perfection of the telephone system, and apparently as a condition of a profitable compromise, the general adoption of a system of twin wires. The public, of course, are not aware that if twin wires are adopted it will be in obedience to the calls of the service which tend in that direction; that they would have come just as soon, or will now be delayed just as long, as would have been the case whether the New Telephone Company had existed or not. The twin wires have been made so much of that the *Financial News* has now come to regard them as aiding "rapidity of connection."

The public were first prepared to appreciate the benefits which the New Company's service would afford by an organised and determined effort to decry the old. Systems were described and estimates furnished, and the hollowness of both exposed by us. The "watered" capital of the old company was a powerful and frequent argument by the advocates of the New Company, and now the pseudo public benefactors are helping to water it still more. The terms of amalgamation are stated by the *Pall Mall Gazette* to be that the shareholders of the New Company are offered three options: They may either accept £5 in cash for each New share on which £4 is paid, or a fully-paid £5 share in the National; or, as a third course, the shareholders in the New Company may pay up in full their £10 shares, and for every 10 receive 23 of the National. In other words, they would receive a premium of £15 on their £100, taking the shares at their par value. If the third option is chosen, the balance remaining uncalled on the shares must be paid up at once.

The capital of the new company is £750,000, of which the National subscribed one-third, leaving £500,000 for general subscription; £90,000 was paid to the Pioneer Company, and the additional capital available for telephone extension is, therefore, somewhere about £400,000, which will be doubtless more profitably expended now than in a useless struggle between competitors. Much, however, as we believe this to be the case, we cannot regard the transaction as satisfactory. It cannot but reflect discredit on those who now urge the advantages of combination, and in doing so eat their own words as to the advantages of competition. It is, no doubt, to the National Company's advantage to remove a competitor from its path, and to the New Company's advantage to secure a certainty of immediate gain instead of running the risk of ultimate loss; but if the

public utterances of public men are to be received with credence, it behoves the promoters of the New Company, their aiders and abettors, either to admit that they were mistaken in their expectations of the rewards of a separate existence, or to leave us to infer that when the Lords of the Treasury restricted the issue of licenses in order to prevent the formation of companies solely for the purpose of being bought up, they were acting rather late in the day. As a financial transaction, we do not doubt the New Company will find many admirers for the management which has enabled them to make the success which they have undoubtedly made; but it must not be overlooked that the limitation on licenses has created the principal element of value, and the appearance of competition seemed to lead to the limitation of licenses. With the aid of that section of the Press which were prepared to take as gospel all the utterances of interested advocates, these appearances of competition and reliability were maintained, with what result is now seen. Regarded as a monetary transaction, it may be left to those who can appreciate it; but a mild protest may properly be made against the hypocritical use of such phrases as "public benefit," and "improvement of telephone service."

A New Ozonising Apparatus.

INVENTORS appear to be convinced that a magnificent fortune awaits the man who succeeds in producing a perfect ozonising apparatus, and the changes continue to be rung upon the various possible methods of generating ozone by electricity. Ehlis's (of Liége) new apparatus consists of a wooden box supported on four feet, and entirely open towards the bottom. The cover is pierced with a hole, in which is screwed a trumpet-shaped mouthpiece or inhalation tube. A sealed glass tube containing air, under more or less pressure, or in which a more or less perfect vacuum has been produced, passes through holes in opposite sides of the box. To one end of this tube is attached a terminal, which is connected to the positive pole of a coil, "or other source of electricity." Inside the box, parallel to but not quite touching the tube, are two insulated metallic plates, one on each side. These plates are connected to the negative pole of the coil. When an electric current is passed into this apparatus a silent discharge takes place between the tube and the metallic plates, resulting in the ozonisation of the surrounding air. The latter is then inhaled by means of the mouthpiece mentioned above, or it may be allowed to pass into a room or hall for the purpose of purifying the atmosphere.

Note on the Theory of Magnetisation.

IN a recent analytical investigation by Dr. Wassmuth, he considers to what extent the introduction of the idea "magnetic resistance" in a special case is justifiable. The case examined is that of the magnetisation of an incomplete ring, one, that is to say, which has an air-break, and is wound uniformly and completely with wire. By using a rapidly converging series, he obtains the following expression for the number of lines of force as a close approximation:—

$$N = \frac{4\pi s i}{\frac{l}{K R^2 \pi} + \left(\frac{2\pi k}{K^2} - \frac{l}{R}\right)\frac{\lambda}{R^2 \pi}}$$

where i is the strength of the current, s the number of all the windings, l the mean length, and $R^2\pi$ the section of the ring, λ the length, and $R^2\pi$ the section of the air-break, and $K = 1 + 4\pi k$ the coefficient of magnetic permeability. Dr. Wassmuth points out that in the denominator on the left hand side of this equation there is actually, along with the magnetic resistance of iron, a sum which is proportional to the ratio "length": section of air-break, and which can be taken as the magnetic resistance of the air-break. Further, he notes that this calculation shows us also that the factor with which this ratio $\frac{\lambda}{R^2\pi}$ appears multiplied differs from unity, by which what is sometimes called "the dispersion of magnetic lines of force" finds an explanation.

The Vanishing Point of the Resistance of Platinum, &c.

IN connection with Profs. Dewar and Fleming's recent work on the electrical resistance of certain metals and alloys at very low temperatures (noticed in the ELECTRICAL REVIEW a few months ago), and the suggestion that they made, namely, that the resistance of certain pure metals, notably platinum, vanishes at absolute zero, a paper recently contributed to the Cambridge Philosophical Society, by Messrs. Griffiths and Clark, is interesting. From an examination of a number of platinum thermometer constants, they adduce evidence which seems to corroborate the conclusions arrived at by Profs. Dewar and Fleming. They consider that there is every reason for believing that the rise in temperature of the platinum wire in such thermometers, caused by the current necessary to determine its resistance, is greater than is usually supposed. If the difference of potential at the ends of the wire is kept constant, the effect of the error thus introduced is to make the absolute zero too low; if, however, the current is kept constant, the absolute zero works out too high. The discrepancies thus caused have probably concealed until now the fact, if it be a fact, of the conclusion which Profs. Dewar and Fleming have deduced. In their paper Messrs. Griffiths and Clark suggest a simple method of graduating platinum thermometers, and conclude that they would, if of the H pattern described in the British Association Report on Electrical Standards, 1890 (reprinted in the ELECTRICAL REVIEW, No. 670, p. 363), be a convenient instrument for the determination of very low temperatures when an error of 0·5° is immaterial; and that further light on platinum thermometry only strengthens their belief in its correctness over the range — 273° to + 700° Centigrade.

A Paper by Lord Rayleigh.

THE remarkable formula, arrived at almost simultaneously by L. Lorenz (*Wied. Ann.* 1880, xi., p. 70) and H. A. Lorentz (*Wied. Ann.* 1880, ix., p. 641), and expressing the refractive index and density, is well known; but the demonstrations are rather difficult to follow, and the limits of application are far from obvious. Indeed, in some discussions the necessity for any limitation at all is ignored. Bearing this in mind, Lord Rayleigh's paper on the influence of obstacles arranged in rectangular order upon the properties of a medium (*vide Phil. Mag.* for December) will be regarded as an important contribution. This paper extends over upwards of 20 pages, in the course of which the secretary to the Royal Society considers the problem in the more definite form which it assumes when the obstacles are supposed to be arranged in square order, and shows how the approximation may be pursued where the dimensions of the obstacles are no longer very small in comparison with the distances between them. The application of the results to the electric theory of light is especially interesting, but the paper, even in its results, is of too mathematical a nature for useful condensation to these pages; the beauty of the method employed, and the value of the results, will only be duly appreciated by those who can find an opportunity of studying Lord Rayleigh's original paper.

THE ELECTRIC LIGHTING OF BRESCIA.

[FROM OUR OWN CORRESPONDENT.]

THE title of this communication might be more correctly: "The Maintenance of Gas Lighting in Brescia," since the steps which the authorities of the town have taken in the supposed interest of the introduction of the electric light are simply calculated to secure the existing gas lighting for a long time against the competition of the electric light. The town has invited a competition with the view of granting a concession for the construction and carrying on of electric works. But the points laid down in the schedule of conditions are such as to exclude anyone from undertaking the work. Hence the gas company will, in fact, if not in name, possess a decided monopoly.

In illustration of what has been said, I will give the most important paragraphs of the schedule, premising that the average price of gas at Brescia, deducting discount, &c., is 20 centesimi per cubic metre, consequently not even 2d., and that consequently it would be very difficult for a newly created electric installation to compete with gas at such prices.

Section 2.—The conceded undertaking has the exclusive right to put up electric leads, aerial or underground, for public and private lighting, and for the use of current as motive power, and as a source of heat within the city, in the streets and squares of the suburbs, as far as a distance of 200 metres from the furthest electrical lamp.

The city, moreover, will permit every private person, every moral (!) association or industrial or commercial company to erect a separate installation for lighting or for motive power, for the exclusive use of their building or establishment.

Section 9.—The leads may be carried in the air, but the municipal committee may prescribe underground leads for any sections where, in their judgment, the local conditions may render it desirable. (Hence the town has the power to limit or to annul at pleasure the concession for aerial conduction.)

Section 10.—The leads for public lighting in the city must be independent of private lighting, if the production of the current takes place within the city, or within the distance of 1 kilometre. Both in this case, and if the production of current takes place at greater distances, the circuits for public lighting must be distinct from those for private lighting. Further, those for arc lamps to burn all night must be separate from such as are to burn half the night, and from those which feed glow lamps for public lighting, so that an interruption in one of the circuits named may have no effect upon the others.

Section 12.—Whilst the city reserves the right to fix the exact position of the several lamps at the time when the works are executed, it is already decided that the public electric lighting along the net A, in the streets and squares is to be effected with arc lamps, each of 500 candle-power, and along the net B, with glow lamps of 50 candle-power. There are to be 24 arc lamps burning for 2,000 hours, and 27 arc lamps burning for 3,720 hours. The places of these lamps are given in full.

On net B are to be arranged 20 glow lamps burning for half the night, and the same number burning the whole night.

The city pays, therefore, only 8,000 lire for 148,440 burning hours of arc lamps, and only 1,750 lire for 106,000 hours burning of 50-candle glow lamps! (See Section 15.)

Section 13.—The energy required for the public arc lamps must be 225 watts per lamp, and that for the glow lamps 130 watts each. The average effective illuminating power must not be less than 500 and 50 candles per lamp respectively. If other lamps are used, whether for private or public lighting, the uniformity of the current traversing the several lamps must be the same which they show at the time of their installation.

In disputed cases the constancy will be determined by a technical commission specially nominated by the municipal committee.

Section 15.—For lighting the streets and squares along net A, the community will pay the contractor the yearly sum of 8,000 *lire*, and for those on net B 1,750 *lire*.

Three years after the conclusion of the agreement the city may extend the lighting to other streets, or undertake alterations in the nets above named. In this case the yearly payment will be made on the basis of the above-named figures, according to the number of lamps supplied. The concessionary will be bound to carry out such installation without increased claims. (The city hopes to find an undertaker on such terms!)

Section 17.—The price for private lighting will be fixed according to the basis of the constants of the current which arrives at each lamp. In any case, the price of consumption for 100 watt hours must not be higher than 10 centesimi ($= \frac{1}{10}$ lire). This price includes the cost of the glow lamps and the carbons of the arc lamps for normal consumption according to the first purchase regulated by section 31, as the lamps must be exchanged by the contractor, but only when the consumer can produce them in an unbroken condition. The *quota* for the communal tax, and the hire for meters and regulators, are not included.

Section 21.—In case it appears that a regular service, public or private, is not practicable, the concessionary incurs a penalty of 20 lire daily until the supply of light is duly effected. The city is entitled at once to take the necessary steps for removing the irregularity, at the expense of the concessionary.

Section 26.—During the continuance of this agreement the city reserves to itself the right of experimenting on whatever system of electric light, whether in order to study improvements in the existing system or to prepare for other concessions on the expiry of the present agreement.

The concessionary must not only throw no hindrances in the way of such experiments, but *must supply such apparatus as the city may demand, as well as the necessary current and the labour!*

AN ELECTROLYTIC THEORY OF DIELECTRICS.

IT is well known that a displacement of electricity along the axes of certain crystals is capable of accounting for the phenomena of both pyro and piezo-electricity observed in them, the fact having been pointed out by Lord Kelvin in 1878. Such a displacement may be conceived of as taking place in one of two ways, namely:—

1. By the separation of the two electricities within previously unelectrified conducting atoms or molecules.

2. By the relative motion of two sets of initially and oppositely charged molecules, distributed throughout the crystal.

There seems to be no third way for the displacement to occur if electricity cannot exist apart from matter.

To explain the displacement by the first of these hypotheses amounts, in the present state of our knowledge, to little more than a confession of ignorance. The mechanism for such a process has not yet been invented. But with the second hypothesis the case is different. Given a certain arrangement of unalterably and oppositely charged molecules, and both pyro and piezo-electric phenomena follow at once from mechanical principles. Moreover, it is possible to calculate an approximate value for the molecular charges assumed; and the fact that this comes out of the same order of magnitude as that of the charges carried by ions in electrolysis lends no little support to the view that such charges exist.

This is the attitude adopted towards the problem by Mr. A. P. Chattock, who contributes a long account of experimental work performed by him at University College, Bristol, to the December number of the *Philosophical Magazine*, pages 461—481. These experiments are well worth following in detail, for although Mr. Chattock takes a modest view of his work (concluding his paper with the following:—"It is the cumulative value of these results which will, I hope, be regarded as sufficient reason for the publication of what is at best an incomplete piece of theory"), the evidence which he is able to adduce bears out the theory suggested very strongly.

So far, at any rate, as Mr. Chattock's results are concerned, it will probably be admitted that the hypothesis of initial ionic charges is the simplest and most consistent method of

explaining them. Indeed, if it were not for the difficulties met with in the consideration of elementary substances, and especially of metals, one would be tempted, says Mr. Chattock, to imagine that chemical affinity and ionic attraction were one and the same thing. The difficulty, however, of accounting for opposite charges in similar particles—the fact that the pairing * tendency is so small in metals that monatomic vapours are the rule—the low compressibility of liquid mercury, which also points to incomplete pairing—and especially the fact that metals conduct without any apparent convection of their particles—all these points are clearly opposed to the idea that the particles of metals are oppositely and permanently charged.

It is true that the phenomena of thermo-electricity like all other cases where electricity is produced by apparently non-electrical means, are likely to find an easy explanation if the previous existence of electricity, *as such*, in the substance is postulated. So, too, magnetic permeability might conceivably be due to the spinning of permanently charged atoms. But these, as Mr. Chattock says, are the only indications of internal charges in metals that he is aware of, and they are very slight.

On some grounds, it almost seems as if the force of chemical affinity in some way, passes over into that of ionic attraction, either during, or after, or even just before, the act of combination of *unlike* particles, while from symmetry, it remains unaltered in the case of *like* particles. The possible equality of the two forces lends some colour to the idea. There is, however, plenty to be said against it. If more were known of the manner in which monatomic vapours conduct, there would be a better chance of coming to a conclusion on this question. As it is, it must be left for the present as a serious, but perhaps not insurmountable difficulty.

A PHOTOMETRIC STUDY OF ELECTRIC LIGHTS.†

By NELSON H. GENUNG, B.S.

In a complete study of the sources of artificial illumination, quality as well as quantity must be considered. A photometer which will supplant the spectro-photometer as commonly employed, with all its long and tiresome processes, one which will enable the observer to explore the visible spectrum both rapidly and accurately, will doubtless prove a useful addition to every photometer room. The "horizontal slit" photometer, recently designed by Dr. Nichols to meet these demands, has greatly facilitated work in this department of physics.

This instrument consists of a direct vision spectroscope

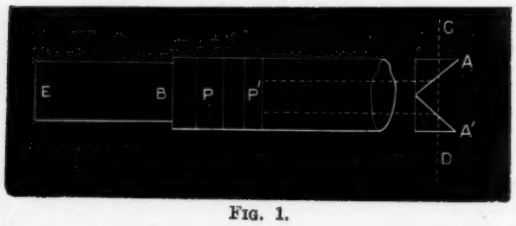


FIG. 1.

(figs. 1 and 2), with a horizontal slit. Immediately in front of the slit are two totally reflecting prisms, A, A'. The light from the direction, C, is reflected through the slit and the dispersing prisms, P, P', producing a vertical spectrum viewed by means of the eye-piece, E. Similarly the light from the direction, D, is reflected by the prism, A', into the slit, and a spectrum is produced parallel to the spectrum from the direction, C. The eye-piece is furnished with a horizontal cross-wire and a diaphragm with a narrow, rectangular opening, through which corresponding portions of the two spectra may be simultaneously seen. The eye-piece with the first joint of the telescope is movable about B, the centre of a graduated semi-circle. This whole arrangement is mounted on a car so as to work the same as the ordinary Bunsen photometer.

On increasing the candle-power of an incandescent lamp from 4 to 28 candles, the brightness of the spectrum near the A line increases in the ratio of 1 : 3·7; while the corresponding increase in the neighbourhood of the G line is 1 : 22. It has previously been noted that at a certain point in the spectrum, approximately $\lambda = 600$, the ratio of the increase in brightness is identical with that of the increase

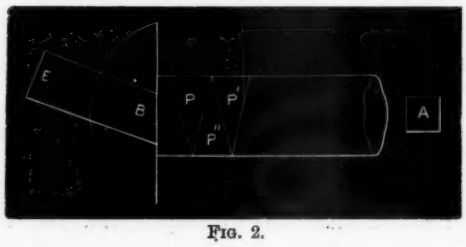


FIG. 2.

in candle-power as indicated by the Bunsen photometer. The vertical line (fig. 3) indicates this region.

M. Crova, in a recent communication to the Electrical Congress at Paris, recommended that on a light differing widely in temperature from that of the standard, the arc light in particular, the wave length, $\lambda = 582$, be employed. As yet this wave length has not been satisfactorily established. When once permanently settled upon, photometry will be reduced to a comparison of intensities from the two sources of this particular wave length, and thus much of the personal error will be eliminated. But we can plainly see that any personal error, whether due to the Bunsen photometer or to the "horizontal slit" photometer, or both, will shift the position of the crossing point. It, therefore, seems necessary that each observer should establish definitely the wave length of this region before he can employ this method of photometric study. The term crossing point will here be used as indicating the wave length which, in the "horizontal slit" photometer, gives the same candle-power reading as does the Bunsen photometer.

1.—THE INCANDESCENT LAMP.

A set of observations taken by the writer on an incandes-

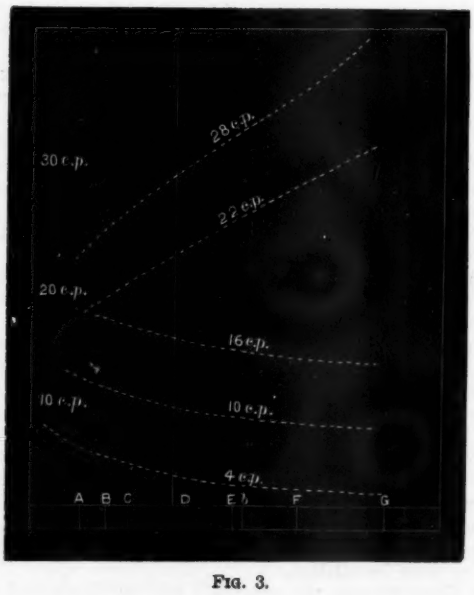


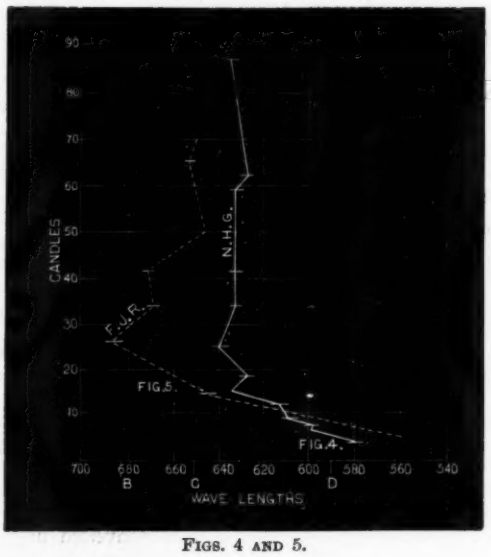
FIG. 3.

cent lamp at six different temperatures disclosed curves similar to those in fig. 3, with a slight exception. The crossing point apparently moved toward the longer wave lengths of the spectrum, starting at a low temperature,

* Mr. Chattock uses the word *pairing* for convenience in indicating the combining tendency of oppositely electrified particles, or, rather, the reluctance of the two electricities to part company while the substance expands and disintegrates under the action of heat.

† From the Cornell *Crank*.

until about 20 candle-power was reached, when it directed itself toward the shorter wave lengths as the temperature of the filament was farther increased. Much longer and more carefully observed sets of observations verified this preliminary study. In figs. 4 and 5 the crooked vertical lines



FIGS. 4 AND 5.

connect the crossing points of the curves taken at the several different temperatures of the lamp filament, by two different observers, denoted by N. H. G. and F. J. R.

A number of sets of observations were next taken by the two observers at temperatures within the range of the incandescent lamp, each observer using the wave length which from the curves seemed to be best suited to his individual case. First, one observer would set the two photometers alternately until five observations had been taken on each, then the other would take a similar set, and so on. In order to avoid the necessity of changing photometer cars, a small Bunsen photometer was mounted directly over the "horizontal slit" photometer on the same car with it. It is eminently proper to call attention to the fact that the settings of one observer were read and recorded by the other, and that after each reading the photometer car was moved to one side at least fifty centimetres, and the observer changed his position before the next setting was made. In all the sets on the arc, as well as on the incandescent lamp, not a single observation was rejected, however far out it might be. By thus not allowing the observer to have the slightest knowledge of any previous settings, he is unbiassed in his judgment as to when the lights from the two sources are of equal intensity.

The following table gives these results in which No. stands for the number of observations in each set; λ, the wave length employed; B and H, Bunsen and "horizontal slit" photometer readings in candles. The last two columns for each observer give the mean error of a single observation for each photometer.

	N. H. G., Observer.					F. J. R., Observer.				
		Candle-power.		Per cent. mean error, single ob.			Candle-power.		Per cent. mean error, single ob.	
No.	λ	B	H	B	H	λ	B	H	B	H
10	618	2·37	2·52	3·0	4·5	640	2·37	2·76	3·3	2·5
10	618	9·06	8·98	2·7	3·8	640	9·15	9·07	2·5	3·0
10	618	16·15	16·87	2·0	3·5	640	15·89	16·68	2·1	3·5
10	618	31·06	31·67	1·9	3·6	640	31·57	31·15	2·1	3·0
10	918	43·58	43·02	2·8	4·2	640	45·12	44·88	3·2	5·7
25	618	34·05	34·62	2·3	4·1	632	35·25	34·20	2·8	5·3

II.—THE ELECTRIC ARC.

In this part of the work the light was taken from the arc at an angle of 35 degrees below the horizontal plane. This was thought to represent the light at its best, at the same time giving a good amount of light from the positive carbon at its hottest point. In order to cancel the fluctuations of the arc, the Bunsen photometer was removed from the "horizontal slit" photometer car and mounted on a separate car at the end of a long projecting arm which would just allow it to pass over the "horizontal slit" photometer. This arrangement enabled the two observers to set the two photometers on the same lights independently and simultaneously. First, however, two Bunsen photometers were used. Twenty-five simultaneous settings on the arc light gave the following results:—

	Candle-power.	Mean error of single observation.
N. H. G.	481·7	10 per cent.
F. J. R.	479·5	11·6 „ „

A set of 25 observations was next taken, using the crossing points that had been employed in the incandescent lamp work, and then a set in which both observers used the crossing point recommended by M. Crova, namely, λ = 582. In order not to tire the eyes by too constant application, the observers exchanged places after every five minutes simultaneous readings.

	Candle-power.	Mean error.
F. J. R.	Bunsen 508	15·0 per cent.
N. H. G. ...	H (λ = 618) 368·5	14·9 „ „

Reducing each Bunsen reading separately to 500 C.P., in order to cancel the error due to the fluctuations in the lamp, gave 363 C.P. as a mean of the "horizontal slit" readings, with a mean error of a single observation amounting to 6·6 per cent.

The reverse set gave:—

	Candle-power.	Mean error.
N. H. G.	Bunsen 513·6	17·6 per cent.
F. J. R. ...	H (λ = 632) 341·2	20·5 „ „

Reduced to Bunsen 500 C.P., the "horizontal slit" reading is 332 C.P.; error, 8·4 per cent.

Both observers employing λ = 582 gave the following results:—

	Candle-power.	Mean error.
F. J. R.	Bunsen 511	18·6 per cent.
N. H. G.	... H 491	17·3 „ „

Reduced Bunsen 500. H, 483. Error, 7·5 per cent.

Reverse set:

	Candle-power.	Mean error.
N. H. G.	Bunsen 516	14·5 per cent.
F. J. R.	... H 454	14·0 „ „

Reduced Bunsen 500. H, 441. Error, 5·4 per cent.

These sets not giving the desired agreement between the two photometers, the observers took up the work one morning, determined to locate the fault. The crossing points for both observers on the arc light were first determined by means of simultaneous readings, and were, to their surprise, found to be almost identical with those used in the incandescent work and in the first set on the arc lamp.

A set of 25 observations was then taken with the following results:—

	Candle-power.
F. J. R.	Bunsen 688
N. H. G.	H (λ = 618) 656

Reduced H, 500. Bunsen, 526. Error for H, 5·6 per cent.

Reverse set:

	Candle-power.
N. H. G.	Bunsen 594
F. J. R.	H (λ = 632) 523

Reduced H, 500. Bunsen, 559. Error for H, 5·4 per cent.

In these last observations an increase in the candle-power of the Bunsen readings over the "horizontal slit" readings as the work advanced was noticed, which would indicate that the crossing points were moving toward the shorter wave lengths. On completing the set the crossing points were redetermined, and were both found to be not far from λ = 595.

What is the solution? One suggestion may be offered. The photometry of fluctuating and intensely bright lights is especially fatiguing to the eyes. They soon become less sensitive to the colour seen in the "horizontal slit" photometer, and while this does not affect the comparison made

with this photometer, it makes the comparison with the Bunsen photometer, a comparison of the lights with this particular colour, less effective. As the arc is rich in violet light it is placed to an advantage with the Bunsen photometer as the eyes become tired, while the "horizontal slit" photometer gives it its true worth.

LONG-DISTANCE ELECTRICAL TRANSMISSION.

UNDER a heading, of which the above is the shortest possible reduction, Mr. B. H. Thwaite read, on November 12th, before the Manchester Association of Engineers, a paper which dealt with the question of transmitting power from the coal-fields to the populous centres by means of electricity generated in close proximity to the coal pits themselves. In this paper, we think Mr. Thwaite is a good deal happier than when he laid his ideas of a novel steam boiler before the British Association; but still we cannot express ourselves altogether pleased with his effort. It is possible that Mr. Thwaite knows the rough diamonds of the Manchester Association of Engineers better than the present writer; nevertheless, we dare to question the wisdom of using such terribly long words in dealing with items of engineering as appear pleasing to Mr. Thwaite. In Lancashire, we have heard such words dubbed eighteenpenny; and Mr. Thwaite seems to be one of those who, when he writes a paper, considers it necessary to paraphrase plain Anglo-Saxon by the use of all the Latino-Greek synonyms he can find in or out of Crabbe. He even appears himself to be dimly conscious of the shortcoming—perhaps we should have written longcoming—for we find him using "tympanum" when he speaks of the ear," and adding "or drum," as though aware of the modest capacity of his hearers, but a generally florid style characterises all which Mr. Thwaite has to write, and he flings in "carbonaceous food elements," and lightly speaks of the "distributed motor elements of the anatomical system." Then he "owns allegiance to the fair goddess Electra," this being his pleasing way of designating electrical engineers.

Intra elements, Swiss patriots, and our national shame of drunkenness, all come in with a crowd of other similar flowers of speech to embellish the introduction to a paper on a mechanical subject which must have called for very considerable work to prepare, and which is quite good enough to stand by itself without such adventitious aids. In support of his views as to the benefits to be derived from the system of power transmission which he advocates, Mr. Thwaite ought not to have perverted facts, but relied on the mere statement of things as they are. We quote directly as follows:—

"Anyone living in a purely agricultural locality, or in towns like Paris, where the ambient atmosphere is free from the polluted emanations from industrial processes, and having the misfortune to be compelled to remove therefrom to towns like Manchester, Bolton, or Oldham, must have been struck with the phenomenally high rainfall average of these towns, and will have noticed the characteristic oily condition of the atmosphere (especially on wet and foggy days), and the greasy condition of the pavements.

"The atmosphere of Manchester having only a moderately high hygrometric character, acts nevertheless in the nature and with the effect of a condenser, for the immense volumes of steam sent into the atmosphere from thousands of exhaust pipes, until the ultimate or saturation point is reached, and the atmosphere being unable to hold in suspension this added aqueous vapour, it is released; and the inevitable rainfall of Manchester follows, bringing with it the hydro-carbons belched forth from hundreds of chimneys. These hydro-carbons, along with the lubricant particles associated with the exhaust steam, explain the greasy condition of the mud in the Manchester streets."

Now, what are we to say to this? Can it be possible that we are expected to believe the large rainfall of Lancashire to be due to the coal consumption? Has Mr. Thwaite ever heard of Seathwaite, in the Lake district? Reasoning by analogy, we should expect to find there cotton mills as thick as flies in a sugar cask, for is not this the wettest place in England—if not in Britain? Mr. Thwaite ought to know that the phenomenal success of the cotton manufacture in Lancashire is due to the very dampness of which he complains. He confuses cause and effect. You cannot spin cotton in a parched atmosphere. Then how much effect have a few paltry tons of water vapour in increasing the atmospheric moisture of South Lancashire, especially when most of the engines condense? Really, Mr. Thwaite!! But we will draw the line, and let the quotation speak for itself.

The subject to which attention is intended to be drawn is that of abolishing the generation of power in towns and cities, and transferring the same to the more immediate vicinity of the coal pits, with the object of securing cleanliness of the atmosphere in towns, and a saving in the expense of carrying coals long distances when electricity will carry itself at the expenditure of a comparatively small effort at the pit bank. It is rightly argued that the production of power can, *ceteris paribus*, be much more economically effected by means of a large high-class generating plant, well kept up, than by innumerable small engines; and, further, any loss in the electrical transmission must be far outweighed by the saving in cost of fuel and labour.

At first sight it would look as though the smoke of the towns were to be transferred to the country, for the presence of a colliery is by no means to be taken as implying that the locality is other than purely agricultural. Not much harm to agriculture arises from a colliery alone. However, such is not quite the idea. It is not proposed to generate power by means of steam engines. Coal is to be converted first into gas, the ammoniacal products are to be saved for manures and other purposes, and the gas used as the fuel of large power gas engines, which will be the prime movers to drive the current-producing dynamos. This is the bare outline of the scheme, which is perfectly good and sound up to a point; but we must be careful not to be drawn too far in this direction. We cannot do everything by electricity as yet, and the idea is applicable only to such industries as cotton spinning, or such manufactures generally as require power only. Were it compulsory on us to burn no coal for manufacturing purposes, save in the vicinity of the colliery, we should very quickly find that our towns would transfer themselves to this locality, and the towns which we had intended to make clean, would be deserted, or become the suburban residences of those who got their living in the new towns.

It is perhaps unfortunate that the unit of power of the cotton mills, about 1,000 I.H.P., is a very convenient one for electrical work, and unless we are to abolish all shafting, and drive every separate machine with its own electric motor, we do not see very well that much advantage could be gained in this direction, except that power during the day could become light by night. In this respect there is a good deal to be said for the double utilisation of factory engines. Why might it not be arranged, in a place like Oldham, that a few of the cotton mill engines should become dynamo drivers by night?

Again, at many factories, a very large amount of steam is used for other than power purposes. There are dyeing, sizing, and various operations in cleaning, scouring, or fulling, which cause a large demand for steam, and, for a scheme to be as complete as Mr. Thwaite would like, it would certainly be needful to convey some of the gas to the town in pipes alongside of the electric mains, or otherwise we should still need a boiler and a chimney, and we should still require the services of an engineer and a stoker, and all the while we should be paying our quota to the cost of the engineers in Centreville. There is an item to which we are now merely about to draw attention, because we know it is not recognised, though it stands out in bold relief for those to see who have eyes. There is a good deal talked of the losses from friction in a textile factory, but it may be very fairly doubted if there is any loss in the sense intended to be conveyed by those who talk so glibly about it.

In a cotton or woollen mill steam is kept on all night, to keep warm the mill. If this were not done, there would be thousands of broken ends in the first few minutes' run next morning, the cotton would be badly carded, and the engine would barely be able to turn the chilled machinery. Now, after running some time, it is possible to turn off some of the steam, and even to shut it off entirely. Why is this? It is not because of the warmth due to the presence of the

workers, but it is because, in the shape of energy locked up in the fibres of the worked material, in the form of twist, there is practically nothing.

What then has become of the 1,000 indicated horse-power shown in the steam cylinders? Part of it has gone, of course, in friction in the engine house; but every foot-pound of work that gets past the driven pulleys—say 750 indicated horse-power—into the work-rooms is, with the exception of the practical nothing above-named, converted again to heat and sound. There is nowhere else for it to have gone. This heat it is which allows the steam pipes to be shut off. But for this frictionally generated heat in the machinery, more steam would be needed in the heating pipes. In this manner a standard Oldham spinning mill receives about 20 million units of heat per diem over and above that due to the direct steam heat. We are not showing that this is an economical means of heating a mill, but that, as some of it arises from shafting friction, any abolition of shafting would by a certain amount increase the further supply of direct heat, and for this, gas must be brought into town as well as electricity. To supply power at ·65d. per horse-power *hour*, as Mr. Thwaite proposes, we may remember that coal costs about 3d. per horse-power *week*, and wages about 1d. per horse-power *week* in a cotton mill, whilst capital costs about 2½d. per horse-power *week*, a total, say, of 6½d. per *week*, or a little over $\frac{1}{10}$d. per horse-power *hour*, and we may add that there is no variation—causing reduced efficiency—in the power demanded from 6 a.m. to 5.30 p.m. in a cotton or woollen factory, so that between $\frac{1}{10}$d. and $\frac{6}{10}$d. there is a wide margin to be bridged over. Where electrical transmission will find employment at first will be for small powers, which are, perhaps, at times fifty times as costly in fuel as large powers. Mr. Thwaite's figures can only be held to apply to small powers. A coal consumption of 2¼ lbs. per horse-power hour is a fairly common rate at a textile factory, including too, all fuel used for millwarming and for sizing, &c.

Now, at present in Lancashire, it is the large factories, after all, which are the smoke producers. The small power men are by no means such sinners. In fact, they almost always have too big a boiler and work this with half-covered bars, and open doors and make no smoke, and this, perhaps, rather than the engine, is the reason they are so wasteful.

We are of opinion that before any great success can attend the scheme, it will be first necessary to improve the system of gas generation and its use in gas engines. There must be a large loss of heat in gas production which goes a long way to reduce its better efficiency in the cylinder, and we think that as a motor for a coal-field station, the gas engine is over-rated, though we are told that a compound gas engine can be obtained to order of 1,000 horse-power. Still, a very good showing is made for the gas engine and for its concomitant economy, the recovery of the ammoniacal distillants.

We prefer to pass over the beneficent agricultural results to be secured all along the electric mains from the coal fields to the big cities, by virtue of the enhanced growth and ripening of fruit along such line. Such a streak of light along England is to make us a fruit-exporting country. It would be interesting to strike a balance between the cost to the farmer at 8d. per unit and the value of the electric growth, but figures are withheld, and perhaps the idea was coruscated merely to brighten the dull and "oily" atmosphere of a Manchester November.

It is decidedly open to question whether, in place of producing energy by burning coal at the pit's mouth and conveying this electrically a couple of hundred miles to London, we could not more cheaply bring the coal to within a few miles of London and there burn it. Mr. Thwaite admits that for every 75 horse-power at the generating station he could get only 54 in London. This is the cost in energy of carrying the power to London.

To carry coal is certainly more costly, but it should not be so. It is less costly in energy, as we may easily figure out. Let us take 30 lbs. per mile as the consumption of fuel in a locomotive drawing 200 tons of coal. This for 200 miles is 6,000 lbs., or less than 1½ per cent. of the quantity carried, a very much better showing than a return of 54 from an expenditure of 75. Railways we must have, and we may as well carry our energy solid in coal as electrically. We do not, in fact, see the proved necessity for so great a length of electric main when a cheaper method is available. At the same time, the idea of extramural generating stations is one to which there can be no objection. It is infinitely superior to stations crowded, as so many in London are, into back streets at enormous rentals, and unprovided with the accessories to economy in fuel consumption, which can only be had where rentals will allow a space sufficient for the purpose.

Thus, while we agree with much that Mr. Thwaite advances, we can hardly concede all the advantages claimed, for the selling price of energy is far beyond the private cost of power, and the call for heat is so common a part of many trades using power, that a steam boiler must, anyhow, be employed. Here comes in the advantage of a modified scheme of a large station near a big city, from which a gas main could be also brought in, a by no means so serious a project as a huge main all the way from Yorkshire.

Let us now see what are the projects suggested.

The Metropolitan scheme of transmission from South Yorkshire by Mr. James Swinburne, conjointly with Mr. Thwaite, proposes to employ 36 gas engines of 300 brake horse-power and 18 alternating current generators, each generator coupled directly to two gas engines, both the field and armature being revolved in opposite directions by a separate engine, so securing a speed double that of an ordinary machine of equal size. These dynamos are to be separately excited by three direct current machines driven by gas engines. Two of these will excite the whole of the large alternators, and the third will be spare; the two being coupled in series, as also are the alternator fields, so rendering parallel running more perfect.

The current proposed is 500 volts and 1,000 ampères from each machine. The omnibus bars of the switchboard are to be connected to a bank of transformers, raising the pressure to 30,000 volts, oil-insulated, of course, and with bare conductors on overhead poles of creosoted timber 30 feet high and oil insulated. This oil insulation is nowadays trotted out much after the fashion that a variety of terms and clauses in so many trades are flung upon the counter of public challenge as a bar to all enquiry. Get a man into a corner in any particular trade or art, and he will flounder hopelessly until he finds his talisman. You can always tell when he has it; his eye brightens and his back goes up, and his demeanour becomes at once ferocious as that of a cat on the tiles. The phrase is duly delivered, and if you are properly subservient to public opinion you have no reply. It is recorded of some schoolboy that he could only repeat his tasks when he had hold of the top button of his vest. Finding this out his rivals cut it off on the quiet, and the boy was floored. So with the high voltage men. They know perfectly well that 30,000 volts has some degree of mischief in it when backed by a large current, but they quell their conscience with oil—oil on troubled waters, and of course we must submit and say nothing.

There will be no fall of potential along the posts, as the insulators are to be earthed by the lightning conductors on each post.

North of London, the receiving station contains the step-down transformers to 2,000 and 5,000 volts, and thence to the present central stations of the various supply companies, who, as it now costs them more than 1·34d. per kilowatt-hour for their home-made electricity, will willingly pay this rate for the supply which is brought to their doors ready made.

For a plant of 10,000 horse-power, including gas generators up to the switchboard in Yorkshire, the estimate of cost is £83,000. This includes sulphate of ammonia plant. The line of 120 miles is to cost a further £80,000, and the remainder, including the London connecting mains, £23,000. The total is thus close on a quarter of a million. Then there are wayleaves and other costs, calling for a paid up capital of £400,000 in all, to deliver 5,400,000 watts in London, or 7,200 horse-power. This is at the rate of £55 per horse-power, a better telling than a petroleum engine at £90 per half horse-power. The moderate estimate of an average consumption of 1,000,000 watts is made on but a fifth of the plant's capacity. At this rate, the charge of 1·34d. per kilowatt is to pay 7½ per cent. dividends, but power is to be sold in large quantities at ·65d. per horse-power hour, though it only costs a private manufacturer $\frac{1}{10}$d. in large quantities.

Mr. Thwaite estimates the cost of conveying coal to

London at 10s. 6d. above its pit-head price. The 7,000 horse-power of his project at 2½ lbs. of fuel per hour would thus cost £28,710 per annum of 7,000 hours, and this would justify an expenditure for electrical transmission of half a million sterling; but, if properly worked, the railways could carry coal for very much less than their present rates, and it would cost far less than present rates to deliver whole train loads to a huge station just outside London, which would avoid the long and costly mains with the loss in transmission over 120 miles. A steady coal traffic carried in special long trucks could be very cheaply managed at slow speeds, and no doubt would be, if the railway companies found themselves in danger of losing business by following in their present short-sighted lines of mismanagement.

In the utilisation of water-power and its conveyance, as in the Tivoli-Rome installation, there appears a much wider field. In this case a waterfall is going to waste, and by means of turbines its energy is converted into a transportable form. The cost of the machinery is small, and there is needed little attention and but few repairs to the turbines, if of originally first-class construction, and the prospects of such schemes are very bright.

With respect to the cost of long trunk transmission lines, it is proposed that as the copper forms the main portion of the cost, and is as good in 20 years as when new, and is not likely to fall in value below 64 per cent. of its cost, a trunk line ought to be built with capital borrowed at $3\frac{3}{10}$ per cent., as a fair rate of interest on so solid an investment. There is a good deal of sound argument in this suggestion, and, taken as a whole, Mr. Thwaite has produced a valuable paper, for he has added appendices giving contractors' specifications for the Metropolitan scheme, as prepared by the Oerlikon Company and Brown, Boveri & Co., of Baden, and also abstracts of the Tivoli-Rome installation, the Frankfort-Lauffen pioneer scheme, and the power plant at the Wolverhampton Works of the Electric Construction Corporation; while Messrs. E. P. Allis & Co., of Milwaukee, furnish particulars of the latest American practice in steam engines for 500 and 1,000 horse-power, which appears to closely follow English practice, except that belts, and not ropes, are employed for the main driving. Thus, at the West End Street Railway Station of Boston there are eight triple expansion engines with cylinders 23, 36, and 52 inches by 48 inches, rated at 1,000 H.P. each, and a smaller engine of 500 H.P. The boiler pressure is 160 lbs., and the fly-wheels are 28 feet diameter and weigh 60 tons, being 127 inches on the face.

In Brooklyn, six engines of 2,000 H.P. are to be used at the North Station, and others of large size for other stations, all to be surface-condensing, with independent air pumps to the larger engines.

Other information is given, and the paper is copiously illustrated with diagrams, maps, tables, and plans; and though we do not see eye-to-eye with the author in everything, it would be ungenerous not to give him credit for a carefully-prepared paper, and to hope that the day may come when the scheme he so enthusiastically advocates will become thoroughly and completely practicable, in a wide sense, of being financially applicable to concerns of 1,000 horse-power, and to the supply of heat for trade purposes as well as of power. Only then can we look forward to the purification of the atmosphere from smoke and grime, and this end to which Mr. Thwaite directs his thought is, we regret to think, the last benefit which will accrue from the extension and cheapening of electricity as a source of either heat, power, or light. The smoke production of a gas works is not great. Electricity has not reduced smoke in giving a better light. Small steam-powers are not smoke-producers; these electricity proposes to abolish. The bulk of our grime arises from domestic fires and large factories, which will be the last to be reached by the cleaner agent.

Royal Institution.—In addition to a number of lectures to be made before this institution before Easter, discourses will probably be given by Mr. Francis Galton, Mr. Alexander Siemens, Prof. Charles Stewart, Prof. A. H. Church, Mr. Edward Hopkinson, Mr. George Simonds, Sir Herbert Maxwell, Bart., the Right Hon. Lord Rayleigh, and other gentlemen.

NEW LIGHT ON SOME OLD IMPOSTURES.

THE remarkable properties of the natural magnet, its capacity for action without contact, and the respective attracting and repelling powers of its two poles, have greatly impressed the imagination of mankind from a very early date; and, as Richer [*Nouvelle Revue*, August 1st, 1882, and *Bulletin de la Société de Biologie*, May 30th, 1884], and Binet and Féré [*Animal Magnetism*, 1888] have pointed out, the assumption that the magnet possessed some mysterious influence on the body, capable of being turned to account in the cure of disease, was prevalent in the middle ages. Magnetic rings were worn to cure nervous diseases, and the follies, and delusions, which are so rampant in the present day, can boast a very ancient history of trickery and credulity. Electric rings, belts and boxes were hung round the body in the time of Cædon: history repeats itself to-day.

Mr. Ernest Hart recently delivered an excellent address at the Sheffield Philosophical Institute on "Hypnotism, Animal Magnetism, and Hysteria," in which, after animadverting on the incoherent teachings of Paracelsus, on Mesmer and his dupes, and kindred matters, concerning which a weekly contemporary has recently treated its readers *ad nauseam*, he proceeds to show that hypnotism, mesmerism, &c., are conditions of disturbed mental equilibrium, the phenomena of which are identical with those of hysteria. By means of photographs, he was able to demonstrate that hysterical conditions could be induced in hypnotics by suggestion, auto-suggestion, and physical impressions. Mesmer only used magnetic and electrical appliances to give colour to his operations, and Mr. Hart boldly asserts that the hypnotic condition is purely subjective.

In repeating the experiments of Braid, whose pamphlet, entitled *Magic, Witchcraft, Animal Magnetism, Hypnotism, and Electro-Biology*, published by Churchill in 1852, was an admirable *exposé* of these kindred subjects, Mr. Hart has proved that the will of the operator has nothing whatever to do with inducing sleep in the patient. He says: "You may, in operating after the varied methods of the mesmerist, the hypnotist, or the electro-biologist, will whatever you please—to sleep or not to sleep. Your will, unless it is expressed or indicated to the patient, so as to afford him a mental suggestion on which he unconsciously acts, will count for nothing: he will fall into a hypnotic sleep. It depends on what he thinks you wish, and not on what you really wish; and if you set before him a glass of water, or a penny postage letter, or put him in front of a tree or a candle, and tell him that you have mesmerised him, and order him to look at it and to be influenced by it, he will be influenced by it whether you have made any passes over it or not; whether you have magnetised it or not; and whether you wish him to be influenced by it or not. You have, in fact, very little to do with it, as the operator, except in so far as you influence by your suggestion, and by his conception of your will his nervous system and his state of mind." So anyone or anything can hypnotise; and only verbally expressed or physical impressions are capable of conveying suggestions. It is unnecessary to drag in the ether theory. The "F. T. S." may study Mr. Hart's paper with much profit to themselves.

Mr. Hart is very strong on what he terms the therapeutic uselessness and social mischief of hypnotism, and is of opinion that its practice should be forbidden, except by skilled physicians, for experimental purposes. Even Prof. Charcot, with his abundant good sense, his great erudition and his vast experience, agrees with Richer, Balinsky Déjerine and other experts, that, hypnotism and its kindred "isms" are, for curative purposes, very rarely useful, generally altogether useless, and often injurious when under the most intelligent direction.

With this paper we may usefully consider some recent researches which have been carried out in Mr. Edison's laboratory by Dr. F. Peterson and Mr. A. E. Kenelly, a well-known English electrician, who has migrated to the United States of America. Their investigation was directed to the influence of magnetism upon the human system, and their results tend to prove that neither direct nor reversed magnetism has any influence on the iron in the blood, or on the circulation, the ciliary or protoplasmic movements, the

sensory or motor nerves, or upon the brain itself. In fact, they are led to conclude from their experiments that the human organism is quite unaffected by the most powerful magnet known.

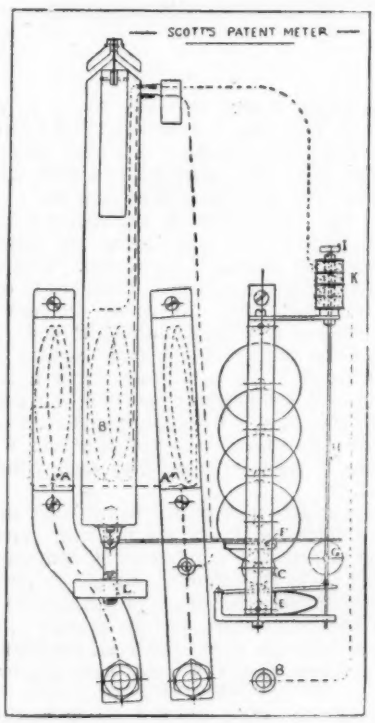
Magnetic appliances for the cure of various ailments are sold in immense numbers to invalids and hypochondriacs who are fain to believe in their hygienic virtues; perhaps for the sake of the latter, at least, it would be a pity to destroy their *crédivité*.

If we had the remotest suspicion that those who reap such golden harvests by their impostures ever troubled to keep up with the literature affecting the treatment of disease, or, indeed, knew anything about physics and chemistry, medicine and surgery, we might hope that such experimental results as we have just described might appeal to their intelligence, to say nothing of their humanity. As it is, we can only trust that the publicity we give to these matters in our pages may have the effect of clearing away some of the fictions which are associated with the greatest impostures of the age by imaginative, ill-informed, or interested persons.

SCOTT'S PATENT ELECTRICITY METER.

THE illustration shows a diagrammatic view of the Scott patent electricity meter, made by Messrs. Laurence, Scott and Company, Limited, Norwich.

As originally designed, a self-winding clock was included in each meter, which made it a somewhat complicated and expensive instrument, as the workmanship in an automatic apparatus of this kind must be very good. By doing away



with the clock in each meter, and arranging one clockwork apparatus in a central position to control the timing of a whole lot of meters, a very simple and practical system is made, which, notwithstanding that a special meter wire has to be laid with the supply mains, works out cheaper, in most cases, than the ordinary system of meters.

The great advantage of the system, however, is that it enables the rates of charge for supply to be made different at different times of the day. This will be referred to further on.

The meter itself is very simple, as will be seen from the enclosed print, which shows all the working parts.

A, A, are the fixed series coils of strip copper through which the current to lamps flows.

B represents the movable shunt coil whose resistance is about 1,500 ohms.

B, X, is the terminal to connect to special meter wire.

C is the friction roller geared to indicating train.

E is a brake to prevent C from being turned round otherwise than by the proper action of the meter.

F is the friction pad, which when lowered on to C will communicate to that roller, and thus to the train, any movement of the suspended coil, B.

G is the roller on vertical carrier, H, which is lowered when the armature, I, of little magnet, K, is attracted.

L is the adjusting weight.

The meter wires in connection with the terminal, B, are periodically connected up to the lighting mains by the clockwork at the central position, or by a relay operated therefrom, so that a shunt current is periodically sent through the suspended coil, B, and through the little magnet coil, K, pulling down the pad, F, on to the friction roller, C, and thus communicating the forward movement or "deflection" of the suspended coil, B, to the roller, C, this movement being exactly proportional to the current flowing in A, A, when the difference of potential at terminals of the shunt coil is constant.

When the shunt circuit is broken by the central clockwork apparatus, the friction pad is lifted off the roller, C, before B commences its backward movement, so that the indicating train is only moved in one direction, and the successive forward movements of B are integrated on it. The meter works on the most accurate principle that is known, and very careful experiments have been made to find out whether there can be any error from the way in which the principle is applied. It has been found that these meters, made as shown in the print, have an accurate range of over 100 fold, and this could be very much exceeded if there were any necessity for it.

The meter is generally arranged to give accurate readings in Board of Trade units when the shunt circuit is completed every 90 seconds. The shunt current remains on for about 12 seconds.

The central clockwork is arranged to make contacts with six separate circuits of meter wires one after the other, and as the resistance of the shunt circuit of each meter is about 1,500 ohms, 45 meters on each of the six circuits, or 270 meters altogether, can be worked with a total shunt current of 3 ampères.

7/20's or 7/18's cable is therefore amply large for the main meter wires, one branch wire of 3/22's being taken from one of these meter mains to each meter on the customers' premises. For long distances and large numbers of meters a relay can easily be arranged in a junction box which will connect the next length of meter wire to the mains synchronously with the first length.

The simplicity and consequent cheapness of this meter will more than balance the cost of the special meter wires in cases where the kind of mains employed permits of these being used.

If instead of sending a shunt current into the meter once every 90 seconds, this interval is increased to 180 seconds, the meters will indicate only half the current used, the clockwork at the central position can be arranged so that the alteration can be easily effected, and if the alteration from a period of 180 seconds to a period of 90 seconds is made, say an hour before sunset by the almanack all the year round, and back again at some fixed time during the evening, it is evident that during the whole of the ordinary working hours in the summer and the greater part of them during the winter, the current will be supplied at half-price, making the cost of power from electric motors compare favourably with that from gas engines. During these hours this will pay the supply companies, as most of their plant would otherwise be standing idle.

It may be objected that this "power" load will overlap the "lighting" load, but during this time the current will be paid for at the lighting rate, and there will be many instances where consumers will arrange so that they do not

use power at these hours, in order to avoid paying the higher rate. It will also encourage the use of electric power during the summer time only, as there are many manufacturers who have steam power that they would gladly stop during the summer months, but which they prefer to run in the winter, as they utilise the waste heat for warming their premises.

The shunt currents can easily be made to record themselves on suitably arranged paper, on which the time of day is also recorded, so that the record can be examined and filed for reference.

THE BACK ELECTROMOTIVE FORCE IN THE ARC.

By CAMILLO OLIVETTI.

THE existence of a negative electromotive force in the arc has been affirmed by many physical scientists and contradicted by others, but I do not believe that it has been yet thoroughly cleared up.

I am inclined to believe that this force really exists, not only because the hypothesis of a back electromotive force is in accordance with results of many observations, but also because I am led to imagine its existence by an *à priori* argument founded on a known phenomenon.

Let us examine a voltaic arc fed with a continuous current burning in air. According to Rosetti's experiments, the temperature of the extremity of the positive carbon is about 3,500° (Cent.) while that of the negative is about 2,000°, and also if these numbers are not absolutely exact, it is certain that there is a great difference of temperature between them. (We shall see subsequently how this difference can be explained.) We have a series of conductors thus formed :—

Carbon—air and carbon vapour, carbon,

and one contact is at higher temperature than the other.

Therefore, we must have a phenomenon similar to the Seebeck effect, that is to say, there ought to be an electromotive force due to this difference of temperature.

However, as we do not know anything about the thermo-electric specific power of carbon, carbon vapour and air, we may say, *à priori*, that this electromotive force tends to generate a current opposed to the principal current.

Indeed, if it would not be so, the energy of the system would be increased without any additional expenditure of energy, which thing, of course, is against the principle of conservation of energy.

If the arc should be in a vacuum, we should have the following series of conductors :—

Carbon, carbon vapour, carbon,

and again the same reasoning is applicable, because a body and its vapour act in their physical properties like two different bodies ; and if we do not admit this view, we should have to think that the Thomson effect is the cause of the phenomenon, and the above reasoning would be valid.

But the Seebeck effect as well as the Thomson, are reversible ; so that when we have a current through an arc, the end of one of the carbons ought to become heated and the other cooled, in accordance with the Peltier effect. In practice this is not really the case, because the ohmic effect prevents it from becoming apparent; but, if my hypothesis is right, the Peltier effect is the cause of the difference of temperature between the two ends of the carbons, which difference is the cause of the back electromotive force of arcs.

Now, let us examine an arc fed with an alternate current. Some experiments show that, according to my latter hypothesis, also in this case, the positive end has a temperature higher than the negative. But evidently, if in one moment one end has higher temperature than the other, with the reversing of the current after a certain interval, it will have a lower temperature.

Therefore, the difference of temperature between the ends will be an alternate function having the same period as the principal current, but getting with it a certain difference of phase due to the fact that in every instant, on account of something which we can call *thermic inertia*, the ends tend to preserve the temperature which they had before. On account of this thermic inertia, we are induced to think that, *cæteris paribus*, the square root of the mean of the squares of such differences of temperature is less than the constant difference between the extremities of an arc fed with continuous current.

In consequence of such an alternate difference of temperature we shall get a back electromotive force with the same period as the principal electromotive force, but having a certain retarding of phase with it.

The value of this electromotive force (being less the square root of the mean of the squares of the differences of temperature) ought to be less than in the arc fed with continuous current. Such a thing agrees with results of experience.

We can also say that this back electromotive force diminishes if the frequency of the current increases, and that the insertion of an arc in a circuit through which an alternate current passes, causes a retarding of phase in the resultant electromotive force, but I do not know if these phenomena were confirmed by any experiment.

This hypothesis for explaining the arc phenomenon does not exclude other collateral causes from entering into the production of the back electromotive force of the arc. But such a view, although sufficiently satisfying the mind and in accordance with known phenomena, needs an experimental demonstration which, I think, that I have obtained in the following way :—

If, really, the back electromotive force of the arc is due to the difference of temperature between the ends of the carbons, and this difference of temperature is due to Peltier effect, being both Peltier and Seebeck effects reversible, we ought to obtain a current if we arrange two conductors in such a manner that their thermic conditions are similar to those of the arc. This proof, being direct, would be sufficient.

For obtaining such a proof, I conceived a little apparatus of which the accompanying figure is a representation. It is composed of two thin pieces, A B, C D, of hard and well-

conducting carbon, measuring about 60 × 10 × 1 millimetres, but the upper one is a little narrower than the lower. These carbons are placed parallel with their faces very near. In order that carbons may not touch each other, although the distance between them is not greater than half a millimetre, I place between the carbons at one end, a sheet of mica M M, which, projecting a little beyond the carbons, serves also as a handle for holding the apparatus. Two rheophores, *p*, *n*, are attached to the carbons. These are, of course, well insulated from each other. A voltaic arc can easily be formed by sending a sufficient current through them, and making the first contact in the same manner as in the Jablochkoff candle. In such a case, if C D is the positive carbon, and A B the negative one, C D will get a higher temperature than A B. We must, therefore, have a back electromotive force having the direction from A B to C D, which is due, if my view is right, to such a difference of temperature.

This electromotive force cannot in this case be apparent, because it is hidden by that of the principal current. But, if instead of getting such a difference of temperature by the Peltier effect (as in the case of the voltaic arc), we get it by heating with a flame, either totally or partially, the piece, C D, to a very high temperature, and the piece, A B, to a lower temperature (although high), such an electromotive force must be apparent, and A B must have higher potential than C D.

This is just the effect which I got by heating with an ordinary blow-pipe, the end, C, of the piece, C D, to white heat, while the end of A B, having greater radiation, was at red hea

Not having a more suitable instrument, I ascertained this difference of potential with a not very sensitive high resistance Thomson galvanometer. Connecting the terminals of the galvanometer with the rheophores, *p*, *n*, when I strongly heated the end of the carbon, C D, I got a deflection of about 3°, which ceased when I did not further heat the carbon.

The insulation between the carbons was very good, and I tested it before and after the experiment. During

the experiment the mica being cold, because it was far from the flame, the conditions were the same. Therefore it is, in my opinion, necessary that the hot air between the carbons, in this experiment, acts like an element of this thermo-elect ric cell, the electromotive force of which can not be very small, being sufficient to overcome such a great resistance. Unfortunately, not having at my disposal any electrometer, or any other suitable instrument, I could not measure this force. This experiment would succeed very much better by using an oxyhydrogen flame, instead of a common blow-pipe flame. It succeeds also if platinum is used instead of carbon, but not to such a marked degree.

Before concluding, I must express my great obligation to Mr. René Upward, who has given literary shape to my conclusions.

MR. THWAITE'S SCHEME.

IT is, perhaps, worth noting that of our two contemporaries who have commented upon the above scheme—the *Electrical Engineer* and *Industries*—by far the more cautious is the former. The latter makes one important statement in favour of the scheme, which, it says, somewhat resembles the American Niagara scheme, viz., that compared with America, we in this country possess an important advantage by reason of England's small area. It concludes that the Niagara scheme must be limited to a very small portion of America, by reason of the heavy cost of copper which would soon put a limit to the distances payably coverable. The whole question, to our mind, is still so much *in nubibus*, that we think this aspect may be left unconsidered, as outside the range of present knowledge to dogmatise upon. *Industries* rather accepts the scheme as it would accept a new railway. The *Electrical Engineer* terms the scheme a "plausible" one, not in disparagement, but in a hopefully doubting spirit. In regard to the motive power—gas engines of large power—our contemporary very rightly enquires, Where can large gas engines be seen by any intending purchaser? How long have they been running? and, With what practical results?

From the manner of referring to Mr. Ferranti's Deptford scheme, we should infer that it is looked upon rather as an illustration of a partial failure in long-distance transmission; but Deptford should not be taken too seriously. When we last were at Deptford, the chimney was delivering steam into the atmosphere, and it struck us as exceedingly comical that alongside the Thames these large engines should be working without condensation. Surely there would be very little expense incurred in laying a water main from the Thames, and so economising a fourth of the fuel burned? Indeed, if we are not mistaken, there is an ample supply of water in the river gravels upon the very site of the engine-house itself. Cautious as we would be ourselves in regard to Mr. Thwaite's idea, we should not exactly take Deptford as a contra argument. Motive power units of 1,000 horse-power would have been quite enough to begin with. It is said that when Brunel was asked if he would build a ship 1,000 feet long, he replied to the promoters they had better begin with a little one of 700 feet; hence the *Great Eastern*, which, even as a little one, has been broken up, now, some years before shipbuilding has produced vessels of even half her tonnage. Gigantic electrical undertakings may find themselves, like the *Great Eastern*, outstripped in usefulness by less pretentious affairs of better design. Heavy works undertaken in times of rapid new discovery savour too much of speculation for the general investor, to whom transmission schemes must look for capital.

RESEARCHES ON THE MAGNETIC ROTATION OF MINERAL ACIDS.

THE subject of magnetic rotation is one which Dr. W. H. Perkin, F.R.S., has made peculiarly his own, the masterly papers in which he, from time to time, describes his investigations in this field of research are in every way worthy of the pioneer of the coal tar colour industry. Dr. Perkin has previously shown that although the molecular rotations of the fatty acids and their ammonium salts are not appreciably influenced by the presence of water, yet that of sulphuric acid is to a considerable extent, the rotation rapidly falling for small dilutions, but diminishing as the amount of water is increased.

More recently, solutions of sodium sulphate and lithium nitrate have been examined and the magnetic rotation of sulphuric and nitric acids, and of their aqueous solutions observed.

In the case of sulphuric acid and sodium sulphate, Dr. Perkin shows that there is no apparent connection between the value for the rotation and the extent to which dissociation is supposed to take place, down to solutions containing about 9 per cent. of acid, or 12 per cent. of sodium sulphate. The same conclusion was arrived at from the examination of solutions of these substances at temperatures of about 90 degrees, when the rotation increased instead of diminishing, as it should have done according to the dissociation hypothesis.

The results obtained with nitric acid gave a different curve when set out graphically to that given by sulphuric acid. Lithium nitrate resembles nitric acid in its behaviour.

Another recent paper on magnetic rotations considered in relation to refractive indices is by Mr. S. U. Pickering. He has been taking the values for the refractive indices of sulphuric acid solutions obtained by Van der Willingen, and has been plotting them out and examining the curves by means of a flexible lath. He states that this method reveals the existence of a well-marked "break," as well as a maximum at 84·5 per cent. (the monohydrate), another "break" at 57·7 per cent. (the tetrahydrate), and another at 24—30 per cent. The first two of these agree with the breaks shown by the magnetic rotations, and all three of them agree with breaks found in the examination of other properties.

These papers were recently read before the Chemical Society, and it is only fair to mention that they did not pass without discussion. Prof. Ramsay criticised Mr. Pickering's method; he entirely dissented from his conclusions as regards "breaks," and denied the existence of anything but continuous transitions from one state to another, quoting a work by Van der Waals on the continuity of the liquid and gaseous states in support of his contention. Dr. Perkin's paper also came in for a share of severe criticism from Dr. Walker, who drew attention to the circumstance that in calculating the amount of electrolytic dissociation from the electrical conductivity of mixtures of sulphuric acid and water, Dr. Perkin had neglected to take account of one of the factors which determine the conductivity, namely, the speed of the ions, which is intimately connected with the viscosity of the solutions. His "dissociation" curves, therefore, did not represent at all the actual degree of dissociation in the strong solutions studied by him, for in them the viscosity is comparatively great. The same objection also, in Dr. Walker's opinion, applied to the temperature experiments. The great increase of conductivity caused by elevation of temperature is due almost exclusively to the increased speed of the ions, and not to any change in the dissociation. In his opinion, therefore, the conclusions drawn by Dr. Perkin as to want of concordance between his results and the theory of electrolytic dissociation were from this cause invalid.

ELECTROLYSIS IN THE PRODUCTION OF ALKALIES, &c.

INCREASED activity is apparent in the application of electrolytic methods to the manufacture of alkalies, chlorine and similar substances, for which there is always a large demand; but many difficulties are encountered in practice. For example, in making chlorine and caustic soda from a solution of common salt by electrolysis, there is a great tendency for chlorinated soda, *i.e.*, Cl Na HO to be found, owing to the re-combination of the chlorine with the soda. Then, again, the progressive weakening of the solution as the chlorine and soda are eliminated, constitutes another drawback to the successful application of electricity in this manufacture. The gist of some improvements designed to

overcome these disadvantages by E. B. Cutten, is to effect the separation of the chlorine gas and the caustic soda by drawing off the gas, as fast as it is formed, by means of a pump, and by allowing the caustic solution which is formed round the wall of the cathode to settle towards the bottom of the cell by means of its own gravity, whence it can be drawn off as convenient. Whilst this subsidence proceeds, fresh quantities of strong salt solutions are forced into the cell at a point below the cylinder which generally surrounds the anode; this solution ascends the cylinder, leaving it near the top, where it is collected, and afterwards strengthened by passing it over lumps of rock salt. Another suggested improvement for obviating these difficulties is to fill the body of the cell with salt; this disolves in the solution as the latter becomes weakened by electrolysis.

More mechanical improvements in electrolytic apparatus for chlorine and alkalies have recently been made by C. Kellner, whose patents in this direction are already legion. His latest idea is to use an iron trough having cast on one of its side walls partitions, which terminate at some distance from the opposite side wall. The trough, with its partition, constitutes the cathodes, and in the intermediate space there are arranged frames of acid or alkali-resisting material, such as glass, stone ware, &c., which contain the anodes and diaphragms. The entire space between the diaphragms is filled with powdered carbon, in which are inserted rods or plates of carbon which serve as anodes. The diaphragms are made of slate or glass pierced with holes.

Another improvement by Kellner is designed to meet a well-recognised difficulty in the separation of the alkali obtained by electrolytic decomposition of halogen compounds from the electrolyte which has been decomposed. As for example when obtaining caustic soda by the electrolytic decomposition of common salt. The liquor containing caustic soda coming from the apparatus is conveyed by means of a pipe to a precipitating apparatus, where it is heated to cause the crystallisation of the sodium chloride. The pasty mass thus obtained is conveyed into a displacing apparatus provided with a perforated false bottom covered with worm wire. A quantity of brine, equal to the amount of caustic soda found by experience to be retained by the crystals, is now added, and the displaced caustic liquor passes over into another vessel, is again evaporated, and the entangled caustic soda is again displaced, and so on, until a caustic soda solution of a very considerable strength is obtained. The salt residue is re-electrolysed.

A recent improvement in the electro-chemical production of bleaching agents is as follows:—The ions separated by the electrolysis are brought into contact with one another outside the decomposing cell to form a hypochlorite. The chlorine gas issuing from the vessel in which the electrolysis takes place passes to the bottom of an absorption tower. The alkaline liquid coming from the cathode compartments, and containing the separated caustic soda, passes into an agitator, where it is stirred violently to free it from any hydrogen gas which may have been carried over with it. Finally, the alkaline liquid is conveyed to the top of the scrubber, and trickles down through the ascending chlorine gas.

OSCILLATIONS THAT OCCUR IN THE CHARGING OF A CONDENSER.

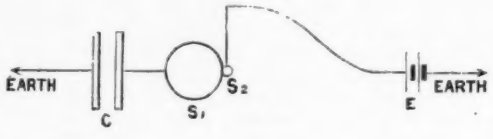
IN some recent measurements of the relation between the charge of a condenser and the time of charging, the latter being made as small as possible, Dr. W. Lispenard Robb has applied an interesting method suggested to him by Prof. H. F. Weber, in whose laboratory at Zürich the experimental work was done.

Fig. 1 represents the connections for charging the condenser, C. E denotes the battery used for charging and S_1, S_2, are two steel spheres. S_1, the larger, was stationary, and in all the experiments a sphere 7 centimetres in diameter was used. For the smaller sphere, S_2, different spheres were used in the different experiments. The smaller sphere was suspended from a fine wire and arranged, as represented in the figure, so that the condenser was receiving a charge only when the spheres were in contact. The condenser was charged by allowing the smaller sphere to swing against the larger and rebound. The length of time that the condenser was receiving a charge could be varied either by varying the size of the smaller sphere, by varying the number of times the spheres were brought in contact, or by varying the velocity of the smaller sphere at the time of contact. The charge of the condenser was measured by allowing it to discharge through a Siemens & Halske high resistance astatic galvanometer, and observing the throw of the needle.

Preliminary experiments demonstrated the important part played by the resistance of the charging circuit in determining the charge given to the condenser in any given time. Hence in all later experiments the battery used in charging the condensers consisted of five accumulators joined in multiple arc instead of two Latimer-Clark cells (Nos. 489 and 491). Further, the connecting wires were made as short as possible, and of No. 11 B.W.G. copper wire, except that used for suspending the smaller sphere, which consisted of soft silver wire 0·05 mm. diameter, and 6 cm. long.

As soon as these changes were made in the battery and connections, it was found that the charge given to the condenser during the time the spheres were in contact was no longer constant, but varied between wide limits, and frequently was much greater than what might be called the normal charge, that is the constant charge which the condenser eventually assumes when charged for a considerable time. These variations and their character seemed to indicate that, during the charging of a condenser, oscillations occurred in the charge. Any variation in the velocity of the smaller sphere at the moment of contact would vary the time of contact, and consequently the charge given to the condenser. Owing to the character of the suspension of the smaller sphere it was found that even when the greatest possible care was taken, slight variations in the time of contact would occur.

FIG. 1.



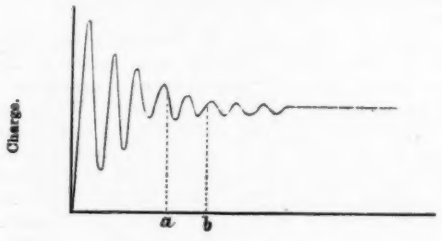


FIG. 2.

If the relation between the charge of a condenser and the time of charging were represented by a curve, such as that shown in fig. 2, owing to the variation in the time of contact of the spheres that always occurs in a series of observations, a series of determinations would give us, not the charge corresponding to any single definite time, but the charges corresponding to a series of different times comprised between limits *a* and *b*, *a* denoting the shortest, and *b* the longest time of contact. Further, the greatest difference in the charges observed would be an indication of the amplitude of the oscillation corresponding to the time of contact.

From certain analytical considerations of the charging of a condenser Dr. Robb shows that oscillations in the charge should occur, and indicates how the oscillations are related to the time of charging, the resistance and self-induction of the circuit, the electromotive force of the battery, and to the capacity of the condenser.

The final expression for the difference of potential of the two surfaces of the condenser is

$$P_1 - P_2 = E - \frac{E\,\varepsilon^{-\frac{R}{2L}t}}{\sqrt{1 - \frac{R^2 C}{4L}}} \sin(2\pi n t + \phi),$$

when C is the capacity of the condenser, E the electromotive force of the charging battery, R the resistance, and L the coefficient of self-induction of the circuit.

This equation is only exact on the assumption that the capacity of a condenser is independent of the time. The capacity being a function of the time (Wüllner, *Sitzungsb. Königl. bayer. akad.*, 1877, p. 1), the equation is simply valuable as indicating the general character of the oscillations, and how their amplitude should be influenced by changes in the values of any of the various quantities that enter into the expression for the amplitude. From it we have the amplitude of the oscillations equal to

$$\frac{E\,\varepsilon^{-\frac{R}{2L}t}}{\sqrt{1 - \frac{R^2 C}{4L}}}$$

Hence it would follow that an increase in the amplitude of the oscillations in the difference of potential of the two surfaces of the condenser corresponds to a decrease in the time or in the resistance, and to an increase in either the electromotive force, the coefficient of self-induction, or the capacity.

Dr. Robb made a number of determinations which are to be considered simply as qualitative in their nature, in order to see to what extent the observed variations in the charge followed laws similar to those given by the above equation for variations in the difference of potential of the two surfaces of the condenser. Two condensers were used in these experiments; one was a standard microfarad mica condenser, manufactured by Carpentier, of Paris, and the other a microfarad paraffin condenser, made by the "Société d'exploitation des cables électriques," of Cortaillod, Switzerland. The experimental results are grouped under the following heads:—

1. Effect of diminishing the time.
2. „ varying the resistance.
3. „ „ electromotive force.
4. „ „ self-induction.
5. „ „ capacity.

Under the first heading there are two long tables of numerical results. An inspection of these tables and of the diagram of curves illustrating them, shows that where the diameter of the sphere, s_2, and consequently the time during which the condenser receives a charge, is increased, the variations in the charge rapidly diminish. Under the second heading there are also two tables and a set of curves, from which it appears that the variations in the charge diminish rapidly as the resistance of the charging circuit is increased.

The results are similarly arranged and illustrated under each of the three other headings, and from an inspection of them it follows that the variations in the charge are increased when the electromotive force of the battery used in charging the condenser is increased; that they are greatly increased by increasing the self-induction in the charging circuit; and that they are also increased when the capacity of the condenser is also increased.

In short, although this work is, as we have said, simply qualitative in its character, one is justified, as a result of the observations, in concluding that *oscillations in the charge of a condenser occur during the charging, and that the amplitude of these oscillations diminishes rapidly as the time increases, and may be increased either by diminishing the resistance, or by increasing either the electromotive force, the self-induction, or the capacity.*

Since completing the experiments upon which these conclusions are based, Dr. Robb has commenced a set of determinations more strictly quantitative in character, for the purpose of deducing the relation between the charge of a condenser and the time of charging, and a further paper in which it is to be presumed the work will be described, will be awaited with interest. The paper from which the above has been condensed is to be found in the November number of the *Philosophical Magazine*, Vol. xxxiv., Series V., No. 210, pp. 389—407.

ON THE VELOCITY OF CROOKES'S CATHODE STREAM.*

BY LORD KELVIN, P.R.S.

IN connection with his splendid discovery of the cathode stream (stream from the cathode in exhausted glass vessels subjected to electric force), Crookes found that when the whole of the stream, or a large part of the whole, is so directed as to fall on 2 or 3 sq. cm. of the containing vessel, this part of the glass becomes rapidly heated up to many degrees, as much as 200° or 300° sometimes, above the temperature of the surroundings.

Let v be the velocity, in centimetres per second, of the cathode stream, and ρ the quantity of matter of all the molecules in 1 cc. of it. Supposing what Crookes's experiments seem to prove to be not far from the truth, that their impact on the glass is like that of inelastic bodies, and that it spends all their translational energy in heating the glass. The energy thus spent, per square centimetre of surface struck, per second of time, is $\frac{1}{2}\rho v^3$; of which the equivalent in gramme-water-centigrade thermal units is approximately $\frac{1}{2}\rho v^3/42{,}000{,}000$. The initial rate at which this will warm the glass, in degrees centigrade per second, is

$$\frac{\frac{1}{2}\rho v^3}{10^6 \times 42 \,.\, \sigma a} \qquad (1)$$

where σ denotes the specific heat of the glass, and a the thickness of it at the place where the stream strikes it.

The limiting temperature to which this will raise the glass is

$$\frac{1}{E} \times \frac{\frac{1}{2}\rho v^3}{42{,}000{,}000} \qquad (2)$$

where E denotes the sum of the emissivities of the two surfaces of the glass in the actual circumstances.

It is probable that ρ differs considerably from the average density of the residual air in the enclosure. Let us take, however, for a conceivably possible example, $\rho = 10^{-8}$, which is what the mean density of the enclosed air would be if the vessel were exhausted to 8×10^{-8} of the ordinary atmospheric density.

To complete the example, take

$$v = 100{,}000 \text{ cm. per sec.}$$

(being about twice the average velocity of the molecules of ordinary air at ordinary temperature); and take

$$\sigma a = \tfrac{1}{8} \text{ cm.},$$

as it might be for an ordinary glass vacuum bulb; and take

$$E = \tfrac{1}{30000},$$

which may not be very far from the truth.

With these assumptions, we find, by (1) and (2) approximately, 1° per second for the initial rise, and 375° for the final temperature, which are not very unlike the results found in some of Crookes' experiments.

The pressure of the cathode stream of the velocity and density which we have assumed by way of example is ρv^2, or 100 dynes per square centimetre, or about 100 milligrams heaviness per square centimetre, which is ample for Crookes's wonderful mechanical results.

The very moderate velocity of 1 kilom. per second which we have assumed is much too small to show itself by the optical colour test. The fact that this test has been applied, and that no indication of velocity of the luminous molecules has been found, has, therefore, no validity as an objection against Crookes's doctrine of the cathode stream.

LEGAL.

NATIONAL TELEPHONE COMPANY *v.* BAKER.

High Court of Justice.—Chancery Division.

(Before Mr. Justice Kekewich.)

FIRST DAY.—DECEMBER 13TH.

THIS was a case in which the plaintiffs, as proprietors of the telephonic system in Leeds, sought to restrain the defendants, the contractor for the electric tramway system in the same town, from so working his electric tramway as to interfere with the proper working of the telephones. Sir Richard Webster, Q.C., M.P., Mr. Warmington, Q.C., Mr. Fletcher Moulton, Q.C., and Mr. Micklem, appeared for the plaintiffs; the Solicitor-General (Sir John Rigby, Q.C.), Mr. Bousfield, Q.C., and Mr. Dunham, for the defendant; and Mr. Morton Daniel on behalf of the Thomson-Houston International Electric Company.

Sir RICHARD WEBSTER said the action was brought by the National Telephone Company and one of its subscribers, a gentleman named Lupton, against Mr. Graf Baker, who was the contracter under whose directions, and by whose plans certain electric tramways were being worked in Leeds, the object being to restrain him from so using his electric tramways as to interefere with the convenient and ordinary use of the telephones which had been established for a great many years in Leeds. He did not think there would be much dispute upon the facts, and although there might be of course substantial arguments as to the legal rights of the parties, he should submit that,

* Royal Society, received December 3rd, 1892.

having regard to the decided cases, there was no doubt as to the principle which his Lordship ought to apply to the case; but it would be convenient if he stated briefly the outline of the facts before touching on the legal principles or upon the authorities. Broadly speaking, the plaintiffs were a telephone company working under the license of the Postmaster-General. The defendant was no doubt a gentleman of skill and eminence, who was seeking to establish in various parts of England a particular system of tramway working, of which he was the main advocate and promoter in this country. That tramway system did, by reason of the way in which the electricity was employed, the high current which was used and the way in which the connections were made, disturb and render useless at repeatedly recurring intervals the lawful user of the telephones by the plaintiffs' customers, and the question was whether, it being as he should submit, unnecessary for the defendant so to conduct his business as to interfere with the telephones, he should not be restrained from so conducting it. It would not be necessary to give any lengthened scientific explanation, but he would very briefly state the outline of the case so far as telephones were concerned and also so far as the working of the tramway was concerned. He was not aware that there was likely to be any dispute with regard to the facts, so far as scientific knowledge was concerned; but if there were, his Lordship would take it, not from him (Sir Richard), but from Lord Kelvin, Dr. John Hopkinson, Sir Frederick Bramwell, and other gentlemen, as to what those facts were. With regard to the telephonic system, there was established a central station from which were taken to various customers separate wires, and at each end there was a transmitting and a receiving instrument. The way in which the sound waves were transmitted was very simple when once enunciated, but was a remarkable discovery at the time it was made, some 12 or 14 years ago, contemporaneously by Mr. Edison and Prof. Graham Bell. Many years ago Faraday pointed out that if a plate of iron was moved across the poles of a magnet, every time it crossed those poles there was an impulse of electricity sent through the line if there was a connection between the ends of the poles; and the same thing occurred if a magnet was moved across another magnet. Mr. Edison and Prof. Graham Bell first discovered that if you put beside a permanent magnet a thin plate of metal and then the voice spoke against that thin plate of metal, the vibrations of the plate in front of the poles of the magnet caused electric impulses to be sent through the line, which by increasing or dimipishing the attraction of the similar magnet at the other end attracted or repelled a corresponding plate, and so reproduced to the ear the sound-waves generated at the sending end. That was what he might call the genesis of the telephonic system. It was then found that by inserting in the line an ordinary electric battery a certain current might be made to flow through the line, and that by the sound waves impinging upon the plate, not of necessity a plate of metal, but a non-conducting plate, the degree of resistance in the line would be made to vary. What was more particularly the invention of Edison was the discovery that if you made the sound-waves which were generated by speaking against the plate, increase or diminish the resistance of the circuit, a greater or less current passed to the receiving end; and again, greater or less current increased or diminished the attractive force of a magnet at the other end, and so again re-produced the sound-waves. The electric circuit must be complete; and, the currents being slight currents, it had been found for many years that the earth could be used as a return "earth" was sometimes used more or less technically, and would mean an uninsulated gas-pipe, or any conductor, the earth itself if sufficiently damp or in the proper condition. The consequence was that although the wire which took the current in the first instance from the sending end to the receiving end would be an insulated wire such as might be seen on the tops of poles going over London, or in cables underneath the ground, the return wire had been dispensed with and the earth was used as the return. That was no novelty in connection with telegraphic transmission. For upwards of 50 years, he believed, the earth had been used as the common return for telegraphic currents; and that would be found to have not an unimportant bearing when he came to deal with the legal rights of the parties, because, as his Lordship probably knew, it had been decided, many years ago now, by the Court of Exchequer, that a telephonic message was a telegraphic message, and since that decision of the Court of Exchequer, which was a decision at the insistance of the then Attorney-General, telephones had been worked under license from the Post Office, as part of the Government monopoly. Therefore, it would be proved that for a great many years the use of the earth as a return for currents of electricity for telephonic or telegraphic purposes was a known use. It would not be suggested, and it could not be suggested, that the plaintiff's use of earth as a return, did harm to any one. It did not in any way affect any other electrical instruments, it did not in any way interfere in the slightest degree with the working of the tramways, nor with any other use of the electric current, so that both in the case of telegraphic and telephonic messages they had a system established which worked effectively and perfectly under ordinary circumstances, and which utilised the earth for the purpose of completing the circuit in the way the earth had been utilised for upwards of 50 years, and without in the course of that user interfering with or doing damage to any person or system. Now, the system of return by earth had been largely used: speaking generally, nine-tenths of the systems in Great Britain had been using earth as a return. In very crowded places where the wires came close together—if, for instance, two telegraphic circuits were very close together on the same post—the curious phenomenon arose that the current in one wire caused by some subtle influence which electricians called "induction," a current either corresponding or in the opposite direction—or some current; there was no need to consider exactly what it was—to be generated in the adjoining circuit, and in some places like the very crowded districts of London, where induction from other messages or from other ordinary causes had been found to be a disturbing influence, the metallic circuit had been completed by a return wire; but it was the fact as he had stated, that nine-tenths of the telephonic business of the country was carried on under the earth return. That was the state of things up to the month of October, 1891, when the Leeds tramway was opened. The electric tramway at Leeds was worked under a provisional order, and he would point out that under that order no statutory power was taken to occupy the roadway by posts. He only mentioned that in connection with a subordinate argument which would afterwards have to be used as to the way in which the defendants were working their tramway; but his Lordship might take it from him that except the authority to lay the rails down in the road, and the authority to erect stations or depôts, there was no statutory authority for occupying the soil of the roadway for electrical purposes. By section 16 of that order it was provided that the carriages used on the tramway might be moved by animal power, and with the consent of the Board of Trade, signified in writing, within a period of seven years, by haulage by wire ropes or other appliances placed under ground, or by means of electrical power, pneumatic power, steam power, or any mechanical power. It would be necessary that his Lordship should bear in mind that the only authorising words were "by means of electrical power," in conjunction with pneumatic power, steam power, or any mechanical power. They might get rid at once of any question as to the consent of the Board of Trade. He did not think it would be disputed that the Board of Trade had no power at all except in connection with the safety of the public. It was not suggested as a matter of law that the sanction of the Board of Trade to the statute authorising the tramway to work in any particular way justified them, if they were otherwise liable, in disturbing the plaintiff's telephones. Section 51 gave protection to the Postmaster-General in respect to the working of the tramways by electricity so as to interfere with telegraphic messages. He mentioned that because it might be said against them that they had no special statutory protection in this provisional order in regard to their telephone wires. His answer was that their rights depended upon protection at common law, and not upon any special statutory protection. In other provisional orders since obtained, a clause was inserted giving special protection to telephonic wires. But in this case he urged his rights in common law, and not by any particular statutory protection. Going back to section 16, his Lordship would notice that they might be permitted to work the tramways by means of electrical power, and he would be told that there were certainly two, if not more, means whereby electrical power might be used as well, as economically, and as advantageously, without in any way disturbing the telephone wires. He was referring now to the principle of the negligent use of statutory powers. One system very largely tried was by carrying electricity on the car itself by means of secondary batteries or accumulators.

Mr. BOUSFIELD said the plaintiffs had not mentioned this method in their particulars of alternatives, and ought not to rely upon it.

Sir RICHARD WEBSTER said the mere question of the number of alternatives had no effect upon his argument. There was also the well-known principle of using an insulated metallic wire as a return. That system had been successfully used, and perhaps the most successful tramway at present known, that at Buda Pesth, was worked upon that system, which could be quite conveniently used without any disturbance of telephonic or telegraphic lines in its neighbourhood. It must not be thought that it was necessary for him to prove economy on behalf of any other system. It had been decided in connection with steam rollers and in more than one other case, that an alternative method was not less obligatory upon the defendants because it was more expensive, if by adopting it they could avoid damage to the persons complaining. Mr. Graf Baker was the advocate and representative of the Thomson-Houston system of electric locomotion, which had been used in America, and Mr. Baker imported into this country the experience of the American use, and he desired to force against the will and against the rights of the telephone companies the use of this particular system of tramway. It consisted of erecting in the road posts from 12 feet to 15 feet high, wires being strung across at a variety of intervals, while from the centre of these wires ran a central conducting wire parallel with the tramway, and upon that central conducting wire there ran a trolley which made contact by means of brushes or some other method as it ran along, communicating the electricity to the motors on the cars, and the return being by means of the earth. In the case of the telephone the current used was quite light; but the pressure of the tramway current was very considerable, something like 300 volts. In addition to that the difficulty, if not the impossibility, of making a good contact between the trolley and the conducting wire was such that the potential was constantly varying, so that there was continuously going on, whilst the cars were running, a discharge of current of rapidly varying intensity to the earth in close proximity to the telephone wires, which in many instances ran along the same streets. This, it would be established by evidence, meant constant and violent changes of current in the telephone circuit by means of induction, which rendered the telephones within that electrical field absolutely inaudible for a space of time, very often many minutes together, and sometimes continuously during the business hours of the day when the tramway was working; sometimes a musical humming would be heard, sometimes a groaning and grunting. Perfectly independent people would give testimony that the effect on the telephonic circuit was to render it for commercial purposes absolutely useless. Under these circumstances communications had taken place between the parties, to which he was not entitled to refer at that stage. Broadly, the telephone company said they had been there for many years in the exercise of a perfectly lawful business under a license from Government; they disturbed nobody and influenced no adjoining electrical circuits; they used electricity in the most ordinary and commonplace way, the novelty of their system being not in the use of electricity, but in the adaptation of currents for ordinary strength used in the ordinary way to the new and delicate instrument, the telephone. Upon that system came in the tramway. It was optional to that tramway to use a system

which would not in any way injure or interfere with the telephone circuits; but the defendant company said they had a right to do what they did, and though, in fact, they disturbed the telephone circuits, they were not liable. Upon this the telephone company claimed an injunction to restrain the defendant and his servants from working or using the tramway or any extension of it in the Borough of Leeds, in such a manner as to cause annoyance to them as owners or users of the telephone lines in the Borough of Leeds. The defendant denied or put them to proof upon every point in the allegations made; his answer was indeed a model of non-admittance. Sir Richard Webster proceeded to quote several cases bearing upon the point at issue. He said he based his argument upon established cases which enunciated the principle that in the first place no statutory authority would justify interference with existing rights if that statutory authority did not involve the necessity of the interference. The best case showing what the statute would justify was Vaughan *v.* the Taff Vale Railway, where, without negligence, sparks came out and did damage, and it was held that no action could be brought. That was the only case that he knew of that had recognised damage done under statutory authority, and it was always pointed out, in connection with that principle, that if there were other methods, or if the legislature did not enforce that particular method, the action could be maintained. Having quoted the case of the Gas Light and Coke Company *v.* the Vestry of St. Mary Abbott, in which the defendants were restrained from using steam rollers of such a weight as to damage the plaintiff's water-mains, and other cases in which a similar point was raised, Counsel concluded by saying that in the course of the case he should satisfy his Lordship that, with scarcely greater cost, certainly with no loss of efficiency, the defendants might conduct their tramway by other electrical methods if they were so minded. It was sufficient for his purpose to point out now that they had no statutory power whatever to use any particular kind of electrical method, and, in fact, there was no demand by the statute that they should use electricity at all, and if they did use it so as to interfere with and do injury to persons who were lawfully carrying on business in which electric currents were essential, he submitted that the action could be maintained.

Dr. JOHN HOPKINSON, F.R.S., was then called and examined by Mr. WARMINGTON, Q.C.: He said he had been consulting engineer to the plaintiff company for the last twelve years. Having explained the mode of telephonic communication, and the enormous difference between the currents required for the telephone and the telegraph, and for electric lighting and traction purposes, the state of knowledge in regard to applications of electricity for traction purposes was practically the same in 1891 as it is to-day, and there was a considerable variety of ways of employing the current. One method was by the use of secondary batteries, the cars, in that case, being self-contained, carrying its own power and running on the rails in exactly the same way as cars drawn by a steam engine or by horses. Another was substantially that used at Leeds, and which was also very largely used in America. In that case the electric current was taken out from a fixed station, where it was generated by insulated conductors, and taken to an insulated conductor running over the tramway; connection was made with the car by means of an instrument something like a fishing rod, attached to a little wheel called a trolley, the trolley being pressed against the lower part of the conductor by means of the fishing-rod arrangement. The current ran through the conductor along the tramway through the middle wire suspended over the tramway, then to the trolley, then to the wire along the fishing rod, and so to the dynamo machine on the car; it passed through the dynamo machine to the wheels on which the car rested, thence to the earth, and back to the station, partly by the earth and partly by an insulated conductor laid between the rails. At Blackpool they had a single conductor arranged in practically the same way, except that the conductor ran through a culvert, a narrow slot which gave access to the conductor, and enabled connection to be made with the car motor. A third way was to have an insulated conductor returning to the station instead of effecting the return by means of earth. This system, also, was used in two ways. At Vevey the conductors ran overhead as they did at Leeds, only in that case there was a metallic return. Still another mode was that employed at Buda Pesth, where a double conductor ran underground in a manner somewhat similar to that used at Blackpool, the current being taken out by one conductor passing through the motor on the car, and going back by the other conductor. In witness's judgment, the system with the two conductors, both insulated, was the most efficient and economical. There were two or three reasons for that. First of all, there was an underground conduit. In order to secure safety, the Board of Trade required that the difference of pressure between a conductor and the earth should not exceed 300 volts. The purpose of that was to ensure the public against serious shocks. Now, if they had both conductors insulated, they could take out the current at 300 volts above the rail, and take it back at 300 volts below the rail, so that they would be able to work with 600 volts, and, moreover, would be able to employ a conductor of half the size, which would mean a further economy in the saving of power. There was a further advantage: With the single conductor and the earth return, if anything went wrong with the outgoing conductor, the whole thing came to a stop; with the insulated return no mischievous consequence would happen. They only had one line of defence broken down, and were simply reduced to the position of the conductors with earth return, and the fact of there being an earth return would be made known to the people at the generating station, who would at once take steps to remedy the matter before any inconvenience resulted. That had been his view for a long time, and when he was at Buda Pesth, where they had a double conductor underground, he asked the conductors of the system there whether they found it of any practical advantage. Their reply was that they would not be without it on any account, and that it was of very great practical advantage indeed.

Mr. WARMINGTON: Then your theory is justified by the experience at Budapest?—Yes.

Now please apply yourself to a case where this electrical traction power is used where there is a telephonic apparatus. From that point of view, state what, in your opinion, is the best mode, having regard to the safety of what is already there.—I would preface that by pointing out the way in which the tramway conductor disturbs the telephone. In order to do that, you must first of all have variable currents, and you do have variable currents with these tramways. That arises from two causes. First of all you do not get a perfectly good contact between the trolley and the wire overhead, or between the wheels of the car and rails. Every variation in contact caused a variation in current, and that variation is at once reproduced upon the telephone in two ways. Then you get variation of current from another source, and that is from the contacts upon the commutator. There are several contact pieces on that commutator, which are constantly revolving, and as the collecting brushes step from one contact piece to another there is a varying current which is reproduced in the telephone. That causes a disturbance of the telephone in three ways. First of all, if you have an uninsulated return from the earth you get disturbances of pressure; in fact, you get part of that current returning to the station not by the rails and not by the non-insulated conductor, but through the telephone line wire and through the telephone receiving instrument. The second way is this: you get the outgoing conductor with its variable current, and possibly in its neighbourhood you have a conductor for telephone purposes. In the first you have a variable current and by magnetic induction, corresponding with the variation of current in the tramway conductor, there is a varying current produced in the telephone conductor, and that current is heard in the telephone. Then there is a third way, which I do not think is important here, and that is by static induction; that, I do not think, is material.

Would the jolting of the car have any effect in an alternating current circuit?—Yes; it would have an effect on the collector above, on the contacts between the wheels and the rails, and probably also upon the contact between the brushes and the commutator of the dynamo machine.

And the varying weight of the car?—Probably not, because the variations are slow, and not rapid.

Mr. JUSTICE KEKEWICH: Does the stopping of the car make any difference?—That has an effect on the note you hear, and the amount of current you are taking. When the car stops there is a cessation of current, and when it starts again there is a low note, which rises almost regularly as the car proceeds, and increases its velocity.

Mr. WARMINGTON: You know the systems of the plaintiffs and of the defendants at Leeds. Is there anything abnormal in the system adopted by the plaintiffs?—No; it is the same system which you find in almost all the large towns of the country.

WITNESS proceeded to state that he had upon two occasions tested the plaintiff's wires for the purpose of ascertaining whether there was any disturbance by reason of the defendants working their trams by electrical power. The first occasion was on November 13th, 1891, when he found a great deal of disturbance. The second occasion was on November 29th this year, when he divided the cases tested into four classes. The first class comprised those cases where the disturbance was excessively loud.

Could you distinguish what it was that caused the noise?—Oh! there was no mistake about that. You could hear the car start, and as its velocity increased the pitch of the note went up, and then you could hear it stop again.

Mr. JUSTICE KEKEWICH: Is there more than one car running over this line?—There were several. I could not say how many.

Mr. WARMINGTON: Could you hear more than one?—Yes; two together sometimes.

One stopping and one going on?—Yes.

Did that interfere with the use of the telephone wires?—Upon the three wires which were the worst it was very difficult to hear, and there were many more cases where it was exceedingly irritating to anyone trying to speak or listen. There were periods when the noise was very small, but I do not remember that there was at any time absolutely no noise at all. It would get very small, and then come out again almost at a roar.

Mr. JUSTICE KEKEWICH: As applied to the ordinary purposes of commerce, for which the telephone is now used in commercial towns, would it interfere with two business men carrying on their business operations?—Of course, they could choose a moment to speak through when the noise was not quite so loud. I should say it would interfere seriously in the first three cases. As regards the other cases, the interference would not be so great, but I would not, myself, care to use the telephone under such conditions.

Would it take more time?—Yes, a good deal more time. I think it might be possible to get your communication through, but with a great deal of irritation. You would have to shout louder. I have no doubt that, one way or another, you could get your message through in time.

Mr. WARMINGTON: But not so conveniently as if there were no such disturbance?—Oh, no. In the other three classes you could still hear the disturbance, but in a lesser degree. I tried some special experiments which satisfied me that the disturbances were due to electromagnetic induction set up along a short piece of line which ran parallel with the electric tramway in the Roundhay Road.

In your opinion is there any difficulty in the defendants so constructing their works as to prevent this disturbance?—Absolutely none. I might almost say this: had they used almost any other arrangement than that they have done, there would have been no disturbance. If they had done it in the Buda Pesth way it would, no doubt, have cost a little more, but it would have given them a system which would enable them to go into Leeds, which they will not be allowed to do as it is; and they would have the advantage of both conductors being insulated, and the consequent security against break-

down. In that case, there would be no induction in the telephone. They might have done it again substantially on the system in use at Blackpool. I think if they had put in an insulated conductor, or had put their wires a reasonable distance from the telephone wires, the disturbance would have been so slight, we probably might have endured it.

(To be continued.)

NOTES.

Gorleston Electric Lighting.—The Ratepayers' Association are protesting against the electric lighting scheme at Gorleston.

Fire.—A small fire broke out at the Windsor electric lighting station last Thursday. The cause was the boiling over of tar.

The Royal Society.—Last evening a paper was read by Prof. E. Waymouth Reid, on "The Electromotive Properties f the Skin of the Common Eel."

Sheffield Electric Lighting.—The Highway and Sewerage Committee notified their intention to lay underground mains in certain streets, but the Highway Committee have expressed disapproval of this.

Bristol Electric Lighting.—As St. Augustine's Bridge is to be opened for traffic before the electric lighting arrangements are completed, standards and globes, suitable for both gas and electricity, are being erected.

Obituary.—We regret to announce the death, which took place on the 8th inst. at Allandale, near Sydney, New South Wales, of Mr. John R. H. Williamson, managing director of the Manchester Edison-Swan Electric Light Company, Limited. He was only 33 years of age.

Cape Town Electric Lighting.—Various schemes for lighting the town by electricity are being considered. Authority has been given for the necessary expenditure for electrically lighting the Houses of Parliament from the Docks.

Northampton Electric Lighting.—Owing to the increased demand for electric lighting, the Electric Light and Power Company, Limited, are laying down additional plant. They are issuing 5,000 6 per cent. £1 cumulative preference shares to meet the expenditure. The consumption is at present two and a quarter times what it was a year ago.

Hampstead Electric Lighting.—The Electric Lighting Committee of the Hampstead Vestry has recommended the vestry to itself undertake the supply of electric lighting in the parish, under the provisional order obtained from the Board of Trade, and to borrow £25,000 for the necessary plant, &c. A special meeting of the vestry is to be held to consider the subject.

Dublin Electric Lighting.—At the meeting of the Dublin Corporation last week, the estimate for the purposes of electric lighting for 1893, £10,180 3s., was adopted. The income estimated to be received from private consumers is £6,066 13s. 4d., and the sum to be brought to credit being excess of credits over debits on foot of estimate for 1891 and 1892, is £4,678 11s. 7d., making a total of £12,745 4s. 11d. This leaves a balance, being excess of estimated income over estimated expenditure, of £2,365 1s. 11d. Soon after these estimates had been passed, the electric light in the chamber went out, and the gas fittings having been already taken away, a few candles had to be procured to continue the meeting.

Eccles Electric Lighting.—The Town Council have decided to apply for an electric lighting provisional order.

Irvine Electric Lighting.—The Irvine Town Council propose to light the streets of the burgh and the harbour with the electric light.

Rothesay Electric Lighting.—The Town Council are considering the question of electric lighting.

Nottingham Electric Lighting.—The Town Council have decided to expend £44,745 on an electric lighting scheme for the central area of the borough.

Leeds Association of Engineers.—The twenty-seventh annual dinner of the Leeds Association of Engineers was held on Saturday evening at the Queen's Hotel. The company numbered about 130.

Bolton Electric Lighting.—At an early date, says the *Manchester Courier*, tenders are to be invited for plant for the electric lighting installation. The corporation are seeking powers to work the tramways, and if these powers are secured it is likely that electricity will be employed.

Plymouth and Electric Lighting.—At the annual meeting of the Plymouth Western District Ratepayers Association, one of the speakers invited proposals from representative associations in regard to electric lighting or anything else for the benefit of the town.

Lectures.—On Monday last Mr. J. Wilson Swan delivered a lecture on "Electro-metallurgy" before the Newcastle Literary and Philosophical Society.

On Tuesday last week a paper was read by E. M. Duncan on "Electric Lighting and Central Lighting Stations" before the University College Engineering Society.

Making Good Use of His Time.—A prisoner in the Maryland Penitentiary, convicted of horse-stealing, made good use of the time he was in confinement. Being a cripple, says New York *Electricity*, he was released from regular work, and spent the time in inventing several articles; two of these were an electric lamp and an electric lamp socket, which were duly patented for him, and some of the lamps will be displayed at the Chicago Fair. Altogether, he has twenty other inventions, which he considers will enable him to abandon horse-stealing when his term of imprisonment expires.

A Flaw Detector—The Schiseophone of Captain de Place, of Paris.—At a recent meeting of the "Academie des Sciences de Paris," October 24th, 1892, Captain De Place showed and explained his new apparatus (called a "schiseophone") constructed for the detection of flaws or cracks in metal pieces. The apparatus consists of a thin hardened steel rod striker, to which an up and down motion is given either by clockwork or manually. This steel rod traverses the centre of a microphone, which is carried on a shaft by means of which the distance between the microphone and the metal under test may quickly be adjusted. A Hughes sonometer with its graduated scale rod carries two coils, of which one is fixed at zero, and is in the microphone and battery circuit, while the second, a movable coil of equal resistance, is connected to the telephone. The operator who desires to test a given piece of metal approaches it to the instrument. In an adjacent room another operator, who wears a head gear to which two small telephone receivers are attached, listens to the noise produced in the receivers, adjusting the movable coil on the graduated scale until there is silence, or a scarcely perceptible sound. If the object under test is perfect, the sound remains the same while the striker of the schiseophone is moved along its surface; on the other hand, the slightest flaw or inequality in the metal is perceived by a sudden change in the volume of the received sound. The instrument has been adopted by the French Government for the testing of armour plates and projectiles.

Dundee Electric Lighting.—The engineer, last week, marked off the sites of the proposed four electric lamps for the High Street.

What constitutes good Vulcanised India-Rubber?—An investigation has recently been conducted by Lieut. L. Vladimiroff, at the St. Petersburg Technical Institute, with a view to establishing rules or tests whereby the quality of vulcanised India-rubber may be efficiently judged. It is a notorious fact that no method of chemical analysis gives reliable results for this substance; hence the tests applied were chiefly of a physical nature. From a lengthy series of experiments the following conclusions were deduced, namely:—1. India-rubber should not give the least sign of superficial cracking when bent to an angle of 180° after five hours of exposure in a closed air bath to a temperature of 125° Centigrade. The test pieces should be 6 centimetres thick. 2. Rubber that does not contain more than half its weight of metallic oxides should stretch to five times its length without breaking. 3. Caoutchouc, free from all foreign matter except the sulphur used in vulcanising it, should stretch at least seven times its length before rupture. 4. The extension measured immediately after rupture has taken place should not exceed 12 per cent. of the original length of the test piece of rubber. The test piece should be from 3 to 12 mm. long, 3 cm. wide, and not more than 6 mm. thick. 5. Softness may be determined by measuring the percentage of ash formed on incineration; it may form the basis for deciding between different grades of rubber for certain purposes. 6. The vulcanised rubber should not harden under the influence of cold temperature. These conclusions are to serve in the establishment of rules governing the introduction of vulcanised rubber into the Russian Navy.

The Panama Inquiry.—In the telegraphed report of the Panama Inquiry in the *Standard* of Tuesday last, the following appears, dated Paris, December 12th, regarding M. Cornelius Herz:—"The *Figaro* this morning publishes a long account of M. Cornelius Herz, the payee of the two largest of the cheques seized at the offices of the banker Thierrée, and his relations with different political personages. The journal recalls how, thanks to the support of the Deputies Sarrien and Clémenceau, M. Herz was able to found the Electric Force Transmission Company, with a capital of 12,500,000f., and how, with the assistance of the newspaper *La Justice*, which was under his control, he was able to carry out a number of important transactions and speculations. M. Herz, the *Figaro* continues, had connections with all the principal Ministers. He thus accumulated a considerable fortune, and was made a Grand Officer of the Legion of Honour. He was closely associated with all the negotiations conducted by Baron de Reinach relating to the Panama Canal Scheme. After the death of the Baron he left Paris for London. The journal adds that the evidence of M. Herz would be of priceless value as regarded the last hours of Baron de Reinach's life, since the latter spent the greater part of the day preceding his death with MM. Herz, Clémenceau, and Rouvier. Only a few minutes after leaving them he returned to his residence, where he died the same evening. This was on November 20th. At 3 o'clock in the afternoon M. Herz left for London. *La Justice* will publish to-morrow M. Clémenceau's answer to the article which appeared in the *Figaro* of to-day. M. Clémenceau denies that M. Cornelius Herz used the paper *La Justice* to assist him in floating various companies and for other transactions. He admits that both Baron de Reinach and M. Rouvier successively visited him the night before Baron de Reinach's death; but he points out that, as he was not at home at the time, he did not see them. M. Rouvier, however, had explained to him, in the lobbies of the Chamber, that Baron de Reinach had been driven mad by the campaign organised against him in the papers. It was for the Baron a question of life or death. The late Baron had wished M. Rouvier to accompany him to the residence of M. Cornelius Herz, in order that he might be induced to use his influence to put a stop to the attacks of the newspapers. He (M. Clémenceau) had then, in company with Baron de Reinach and M. Rouvier, called upon M. Cornelius Herz, who declared that he could not render them the service they required."

Port Adelaide Electric Lighting.—A trial of electric lighting plant has taken place at the English and Australian Copper Company's Works, Port Adelaide. The machinery and dynamo, says *Engineering*, were purchased from the late firm of Hooker & Co., of Kilkenny. The services of Mr. R. W. Thompson, electrician, of Leigh Street, Adelaide, were obtained to erect the plant and to superintend the trial operations. The dynamo is an 8-light one, driven by a small engine worked up to 12 horse-power. Seven arc lamps have been erected, five throughout the works and two on the wharf. Twenty-four incandescent lamps have also been distributed about the furnaces, so that the works are brilliantly illuminated.

The Corrosion of Aluminium: Another Fiction Dispelled.—Amongst the many fictions which have been disseminated concerning aluminium, is that of its incorrodibility by sulphuric and nitric acids whether dilute or concentrated: this statement has, strange to say, been subscribed to by such eminent authorities as Deville, Wustz, Hunt, Langley and Roscoe, whom, it must be presumed, did not use the pure metal in their experiments. Mons. G. A. Le Roy having been induced to study the possibility of replacing lead and platinium by aluminium in various manufactories, has been surprised to find that the statements of these authorities are entirely incorrect on this point. Experiments made with four different samples of aluminium, the composition of which is stated, two of them being made by Deville's process at the old Nautern Works by Messrs. P. Tronin & Co., show that the pure metal is so rapidly attacked by strong nitric and sulphuric acids even in the cold, as to be quite unfit for use in manufactures or processes in which these acids take any part.

Differences of Potential Generated Through Contact of Liquids.—This subject has recently been thoroughly studied by Dr. W. Negbaur, and the results of his experiments show a close agreement between the observed results and those calculated by the formula of Planck,

$$\phi_2 - \phi^1 = \frac{R}{\epsilon} . \log. \xi,$$

in which R is the osmotic pressure, ϵ denotes the electric charge of one univalent positive ion (therefore a constant), and ξ is derived from the equation:

$$\frac{\xi U_2 - U_1}{V_2 - \xi V_1} = \frac{\log. \frac{c_2}{c_1} - \log. \xi}{\log. \frac{c_2}{c_1} + \log. \xi} \cdot \frac{\xi c_2 - c_1}{c_2 - \xi c_1}.$$

In this equation, c_2 and c_1, are the concentrations of the solutions in contact. $U_2 = u_2 c_2$; $U_1 = u_1 c_1$; and here u_2, u_1 are the velocities of the positive ions. $V_2 = v_2 c_2$; $V_1 = v_1 c_1$; and here v_2, v_1 are the velocities of the negative ions.

Solutions.	Results. E.M.Fs. in volt. Observed.	Calculated.
$HCl \mid KCl$	0·0280	0·0282
$HCl \mid NaCl$	0·0333	0·0334
$HCl \mid (NH_4)Cl$	0·0290	0·0295
$HCl \mid LiCl$	0·0358	0·0358
$KCl \mid NaCl$	0·0050	0·0062
$KCl \mid LiCl$	0·0075	0·0087
$NaCl \mid LiCl$	0·0024	0·0024
$BaCl_2 \mid ZnCl_2$	0·0014	0·00145
$HCl \mid HNO_3 \mid LiCl$	0·0370	0·0371
$HCl \mid KNO_3 \mid NaCl$	0·0350	0·0355
$NaCl \mid KNO_3 \mid LiCl$	0·0026	0·0028
$HCl \mid KClO_3 \mid KCl$	0·0360	0·0368
$HCl \mid HNO_3 \mid KClO_3 \mid NaCl$	0·0375	0·0370
$KCl \mid HCl \mid KNO_3 \mid NaCl$	0·0070	0·0073
$H_2SO_4 \mid ZnCl_2 \mid Na_2SO_4$	0·0130	0·0151

Teignmouth Electric Lighting.—At the public meeting held at Teignmouth last week, a deputation was appointed to confer with the Local Board on the questions of gas extension and electric lighting, to ascertain to what extent the ratepayers would adopt the lighting, and to report to an adjourned meeting.

Glasgow Electric Lighting.—There was last week a rumour circulated to the effect that there had been a hitch in the electric lighting scheme, but this is authoritatively contradicted in a letter in the *Glasgow Evening News*, in which it is also stated that the electric current will probably be turned on to the mains in two months.

Southport Electric Lighting.—A Local Government Board enquiry was held last week, when sanction was given for the borrowing of £28,000 for electric lighting purposes. It is proposed to supply 1,900 16-C.P. lamps, although there will be capacity to supply 6,600 16-C.P. lamps. Already 400 lamps have been applied for.

The Tivoli Electric Power Transmission Plant.—The British Consul at Rome, in commenting on this plant in a recent report, states, says *Industries*, that none of the machinery came from Great Britain. This, he considers, is, perhaps, to be attributed to English prices, which are found somewhat too high for success with Continental competition. It is, however, to be expected that for private installations, especially in hotels and houses of wealthy people, good English electric appliances will find a proportionate market.

Chicago Exhibition.—A meeting of the Committee on Electricity was held on the 1st inst. at the Society of Arts. There were present: W. H. Preece, F.R.S., in the chair; Prof. George Forbes, F.R.S., H. Graham Harris, Prof. D. E. Hughes, F.R.S., W. M. Mordey, James Paxman, Mark Robinson, Alexander Siemens, James Swinburne, Prof. Silvanus Thompson, F.R.S., Major-General C. E. Webber, C.B., with Sir Henry Trueman Wood, secretary to the Royal Commission.

Alternating Arcs.—The experiments of M. Blondel, recently described by M. M. F. Guilbert in our contemporary, *Électricité*, are very important in connection with the theory of arc lamps. It has been generally assumed, says *Industries*, that because with a direct-current arc the current increases enormously if the pressure rises, the arc has a back-electromotive force of about 40 volts and a resistance of some half an ohm. On the other hand, it has been said that a back pressure of 40 volts is absurd, and that the conductivity of an arc varies with the cross-section of the heated path through the gases, this cross-section varying with the current so that the observed effects are produced. This explanation certainly seems the most rational. The alternating current, however, affords means for determining this. In Dr. Hopkinson's paper on alternating currents, read before the Institution of Electrical Engineers in 1884, he assumed that the back-electromotive force theory was correct, and worked out the results. M. Blondel's experiments show, however, that a silent arc behaves precisely like a resistance. This is true of the arc itself, but not of the whole lamp, which, of course, contains electro-magnets. The curves of the current and the pressure on the arc itself must be considered. The long and the short hissing arcs, however, both behave as if they had self-induction. It is probable that the effects are due to the gases forming the conducting path having time to cool, by draughts in the long arc, and by conduction to the carbon in the short arc, so that the results would be interfered with. This is only a surmise, and it is difficult to see why there should be any difference in the case of the silent arc. M. Blondel appears to have used low frequencies. It would be interesting to know whether the same results would be obtained with 100 or 120 periods per second.

Falmouth Electric Lighting.—The authorities are making inquiries of two or three electric light companies as to the cost of electric lighting the borough.

School Electric Lighting.—It has been decided to have the Wyndham School, Nantymoel, lighted by electricity, also the new school building at Tynewydd.

Lectures.—Prof. H. M. Worthington, M.A., &c., on Wednesday, last week, lectured on "Dynamos and Electric Motors," before the Plymouth and District Students' Association.

Sutton Coldfield Electric Lighting.—At the last meeting of the Town Council, it was proposed that they take into consideration the lighting of the Town Hall and the Municipal Offices with electricity.

West Bromwich Electric Lighting.—The Town Council were recommended by the Estates Committee to advertise for tenders for electric lighting, but at their meeting last week the matter was postponed for twelve months.

Sunderland Electric Lighting.—A practical man is to be appointed by the Electric Lighting Committee to advise as to the best course to pursue regarding the electric lighting, and as to the probable cost of a scheme. Enquiries are being made as to the probable number of users.

Birmingham Electric Lighting.—The Council are undecided whether to apply for an electric lighting provisional order at present, and they do not consider it advisable to let any company obtain further rights for the city. They, however, desire that the electric light should be at the inhabitants' disposal at an early date.

City and Guilds of London Institute.—The presentation of prizes and certificates in connection with the City and Guilds of London Institute for the Advancement of Technical Education took place on Monday evening at Merchant Taylors' Hall, Threadneedle Street, the Lord Mayor (Mr. Alderman Stuart Knill) presiding. Those present included Dr. Anderson, F.R.S., Sir Frederick Bramwell, Sir Frederick Abel, Sir Philip Magnus, General Moberly, Sir Owen Roberts, Mr. J. R. Diggle, Mr. Herbert Saunders, Q.C., the Rev. Prebendary Whittington, and others. The Lord Mayor, in opening the proceedings, heartily welcomed the students of the Institute to the City. The guilds of the City of London, he said, were always ready to do everything in their power to further the cause of technical education, which was of so much value to the public generally. English people now were much more in favour of technical education than in former days, and the City Guilds Institute had established colleges all round London, having that object in view. Mr. John Watney read the annual report of the Institute's colleges and schools, and said that the highest award the Institute offered to any of its students on the completion of their course of study was the diploma of "Associate of the City and Guilds Institute," which was conferred upon those who had matriculated at the Central Institution, and had successfully passed through the three years' course of study prescribed in one or other of the departments for preparing students to enter the professions of civil, mechanical, or electrical engineering and technical chemistry. In July last 23 students gained that distinction, the highest place being taken by Mr. F. H. Hummel. Certificates had also been awarded to 17 students. At the matriculation examination, held in September, for the current session, there were 107 candidates, of whom 70 succeeded in passing. That was the highest number recorded since the opening of the college. At the Central Institution, Finsbury, there were 860 evening students on the register, the electrical department attracting the greater number of students.

Holborn and Electric Lighting.—Holborn Town Hall is to be fitted for electric lighting at a cost of £650.

Edinburgh Electric Lighting.—A deputation is to be appointed to visit other towns and obtain information regarding electric lighting.

Tunbridge Wells Electric Lighting.—Mr. W. H. Preece has prepared and presented his report on the electric lighting question here.

Penarth Electric Lighting.—The Local Board have postponed the electric lighting question for the present, but are, however, considering whether they shall apply for a provisional order.

Bradford Market Electric Lighting.—The laying of mains for electric lighting the Central Markets was commenced on Sunday last.

Leyton Electric Lighting.—The Leyton Local Board have refused to grant powers to a private company to lay electric lighting mains, and have themselves decided to apply for a provisional order.

A Strike.—The telegraphists on the Georgia Central Railway struck work on the 12th inst., because the superintendent of the company refused to reinstate some discharged operators. A telegram from Chicago on 13th inst. states that the strike was then extending.

The Steel and Iron Trades.—Messrs. Bolling & Lowe have brought out their steel and iron report for the past year. In their report of 1891, they stated that they expected the present year would not show any improvement, and their anticipations have been fulfilled. They consider the prospects for 1893 far from encouraging.

NEW COMPANY REGISTERED.

Walsall Electrical Company, Limited.—This company was registered on the 6th inst. with a capital of £10,000, divided into 1,000 shares of £10 each, to acquire and take over as a going concern, and carry on the business of a manufacturing electrician and electrical engineer, now being carried on by Mr. Frederick Browne, at Walsall, in the county of Warwick, under the style or firm of The Walsall Electrical Company, and to prosecute the business of electricians, electrical contractors, electrical, mechanical, and general engineers, and founders in brass, iron, or any other metal or alloy. The subscribers (with one share each) are: J. Hildick, jun., Walsall, tube manufacturer; H. P. Nicklin, Walsall, saddler; J. W. Fellows, Walsall, surveyor and auctioneer; F. Brown, Walsall, electrical engineer; S. Beebee, Walsall, saddler; T. H. Fellows, Walsall, electrical engineer; Wm. Beebee, Darlaston, cashier. The number of directors is not to be less than three nor more than five. Qualification, £250. Remuneration, £1 1s. for each board meeting, not to exceed £13 13s. per annum. Registered by Frith Needham, 10, New Inn, W.C. Registered office, 57, Bridge Street, Walsall.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Lironi & Bowman, Limited.—In an agreement bearing the date of October 12th last, made between V. G. Lironi and T. Bowman, of Bow Electric Works, E., and the above company, it is stated that the company agrees to purchase the business of electrical engineers carried on by the vendors and certain patents belonging. The consideration was contained in 1,200 fully paid up shares of £1 each, none of these shares being transferable for seven years without the consent of a large majority of shareholders. The company also agreed on October 12th last to purchase some particular plant, machinery, &c., in or about the Bow Electric Works for £1,200. The statutory return was made up to the 25th ult., and shows that out of a nominal capital of £2,000 in £1 shares, the whole of these have been taken up.

London Carbons Manufacturing Company, Limited.—This company is being wound up by the registrar of Joint Stock Companies.

London Electrical Tramways Company, Limited.—This company was registered on April 22nd, 1891, with a capital of £150,000 in £1 shares, to acquire and carry on the system and undertaking of the North London Tramways Company; but is now being wound up.

North-Eastern Telephone Company.—Resolutions were passed at extraordinary meetings of this company, held on November 10th and 29th respectively, to the effect that the concern be wound up voluntarily. Mr. T. D. Chaloner, of Newcastle-on-Tyne, is to be the liquidator.

Holloway Electricity Supply.—The statutory return of this company, made up to the 14th ult., shows that out of a nominal capital of £2,000, in £10 shares, seven have been taken up, but nothing has been called on any of these shares.

CONTRACTS OPEN AND CLOSED.

OPEN.

Brussels.—December 21st. For the supply of galvanised iron wire and other electrical and telegraphic material, for the Belgian Post and Telegraph Direction (Brussels Bourse). Specification, No. 362.

Kiel.—December 23rd. For the supply of copper (block and electrolytic), requirements for 1893-94 for the German Navy. Further particulars from the Director of the Royal Dockyard, Kiel.

Magdeburg.—December 20th. For the supply, 1893-94, of 3 tons of copper plate, 1 ton brass plate, 2½ tons zinc plate, 2 tons of block zinc, 20 tons bar copper, 3½ tons iron and steel wire, 1½ tons brass wire, and 6 tons copper tubing, for the Prussian Royal Railways. Further particulars from the Chief of the Materials Bureau of the Royal Railways, Knochenhaueruferstrasse 1, Magdeburg.

Ostend.—December 28th. For the supply of weldless copper pipes, sheet and bar copper, brass sheets, &c., for the Belgian Marine Service (Brussels Bourse). Specification No. 22.

CLOSED.

Chelmsford Electric Lighting.—The two courts at the Shire Hall are to be lighted with incandescent electric lamps at a cost of about £35, the order being given to Messrs. Crompton & Co.

BUSINESS NOTICES, &c.

The Electric Light in the West End.—Further progress is being made. Amongst the new work in hand we may mention that Messrs. Paterson & Cooper, of Westminster, are fitting up the premises of the London Fur Company, Baker Street.—Contracts have recently been carried out in the premises of Messrs. Cobb & Sons, tailors, and Messrs. Chas. Klein & Co., hairdressers, both in Baker Street.—The Electrical Wiring and Fittings Company, of Duke Street, S.W., are at work in some residential chambers in Nottingham Street.—A contract has recently been carried out in the Welbeck Restaurant, Mortimer Street.—Messrs. Smeeton & Page, of Queen Victoria Street, E.C., are fitting up 71, Oxford Street.—Messrs. E. L. Berry, Harrison & Co., of Whitcomb Street, W.C., are putting up fittings at 10, Regent Street; while the Planet Electrical Engineering Company, of Westminster, are at work in the Café de l'Europe, Haymarket.—A contract is being carried out in the premises of Messrs. H. Turner & Sons, ironmongers, Villiers Street, Strand; while one has recently been carried out at 2, Adelaide Street, Strand.

Bristol Electric Lighting.—At the Bristol Town Council, on Tuesday, the electrical committee reported that Messrs. Woodhouse & Rawson, whose tender for the construction and erection of condensers, pumps, steam and other pipes, was accepted by the Council in August last, had declined to enter into the contract, and the committee recommended the acceptance of the tender of W. H. Allen & Co. to execute the work for £4,201. It was explained that Messrs. Woodhouse & Rawson would not agree to certain clauses in the contract, which they considered severe. The recommendation was accepted.

Wolverhampton Electric Lighting Tenders.—At the meeting of the Wolverhampton Town Council on Monday last, the Lighting Committee presented a report on the question of electric lighting. In response to the advertisements, tenders were received from 15 firms for the whole of the various sections of the works required. The following is a list of these tenders:—

		£	s.	d.
Messrs. Siemens Bros. ...	Scheme 1, complete plant	27,105	5	0
Ditto ditto ...	Scheme 2, ditto	29,345	5	0
The Electric Construction Corporation ...	Scheme 1, ditto	28,614	10	0
Ditto ditto ...	Scheme 2, ditto	30,525	0	0
Messrs. Crompton ...	Scheme 1, ditto	28,628	10	0
Ditto ditto ...	Scheme 2, ditto	31,559	0	0
The Brush Electrical Engineering Company ...	Complete plant	31,229	10	0
Messrs. Mather and Platt	Ditto	42,671	10	0
Messrs. Parsons... ...	Boilers, condensers, engines, dynamos, switchboards, and mains ...	21,563	0	0
Messrs. Statter	Boilers, engines, dynamos, switchboards, arcs, and transformers	18,387	4	0
Messrs. Woodhouse and Rawson	Boilers, engines, and dynamos	16,610	0	0
Messrs. Callender ...	Scheme 1, mains	9,512	0	0
Ditto ditto ...	Scheme 2, ditto	9,438	0	0
The British Insulated Wire Company ...	Ditto	8,671	0	0
Messrs. Thompson ...	Boilers	3,650	0	0
Messrs. Babcock and Wilcox	Ditto	3,780	0	0
Messrs. Johnson and Phillips	Arcs	2,014	17	6
Messrs. Reid Bros. ...	Ditto	2,240	0	0
The Munro Manufacturing Company ...	Switchboards	1,560	19	6

The committee considered the following six tenders: "The Electric Construction Corporation's two schemes—Scheme 1 for high-pressure continuous currents and scheme 2 for high-pressure alternating currents; Messrs. Siemens's two schemes, both for high-pressure alternating current, the difference being in the type of engine and fittings; Messrs. Crompton's scheme 1 for high-pressure alternating currents; the Brush Electrical Engineering Company's scheme for high-pressure alternating currents. These tenders were all admirable, and it was found only necessary to consider the systems proposed and the prices offered. The two lowest were the Electric Construction Corporation's scheme 1 for high-pressure continuous currents, and Messrs. Siemens's scheme 1 for high-pressure alternating currents. After reviewing the merits and demerits of the rival schemes, and by substituting the tender of Messrs. Thompson for boilers for that given by the Electric Construction Corporation, and modifying the other sections, the difference between the two tenders amounted to only £400. On considering the future working expenses of the two schemes, the committee decided that the scheme proposed by the Electric Construction Corporation was the better of the two to meet the requirements of the borough of Wolverhampton. To summarise, the committee recommend as follows:—1. That the tender of the Electric Construction Corporation, Limited, amounting to £28,772 10s., for the construction of the works included in the printed specification, be accepted, subject to certain modifications in the sections for boilers and mains (which will form the subject of a further report), and that the town clerk be instructed to prepare the necessary contract. 2. That Mr. W. H. Preece, F.R.S., be appointed engineer for the purposes mentioned in this report, at the remuneration previously named. 3. That your committee be empowered to appoint an architect for the purposes previously mentioned, at such remuneration as your committee may fix. 4. That your committee also be empowered to appoint a deputy engineer or clerk of the works, at a salary not exceeding £250 per annum, subject to the engagement being terminated by one month's notice on either side. 5. That your committee be empowered to provide an overhead crane for the purposes mentioned in the specification. 6. That in so far as the Finance Committee are not authorised by the report of your committee, dated September 28th, 1892, to do so, they be authorised from time to time to borrow, subject to the approval of the Local Government Board, all necessary moneys, and, if necessary, to raise Wolverhampton Corporation stock for the purpose of carrying into effect the Electric Lighting Order of 1890. 7. That for giving effect to all or any of the foregoing recommendations, the corporate seal be affixed where required.

Ipswich Electric Light.—In the Ipswich County Court on Wednesday last, before his Honour, Hugh Eardley Wilmot, Esq., Laurence, Scott & Co., electrical engineers, formerly of Carr Street, Ipswich, sued E. S. Greenard, manager of the City Clothing Company, Tavern Street, for the sum of £1 9s. Mr. Sisling, manager of the plaintiff firm, explained that this was for renewal of lamps and breakages. In answer to the Judge, the witness said the verbal agreement was that the contract should be the same as with other customers, and as mentioned in the firm's circular. The firm never renewed the lamps, which were left to the care of the consumers, in the same manner as gas burners. After a deal of discussion, judgment was given for the defendant with costs.

Hull Theatre Electric Lighting.—Hull Theatre Royal has been recently lighted with electricity, with a total power of 2,650 candles. The work is in the hands of Messrs. Royce & Co., of Manchester, and the current will be supplied by Messrs. Booth & Co., of Hull.

Electric Lighting at York.—The electric lighting of the York Courts of Justice was successfully inaugurated on the 8th inst. The building has been wired and fittings put in for over 500 lights, and it is proposed eventually to take the current from the mains of the city supply, but as the scheme is not yet completed, a temporary plant has been fixed in the basement corridor for supplying current up to 220 lights, which is estimated to be the maximum number at present required. The plant consists of an 18 I.H.P. Crossley gas engine and a Crompton dynamo, capable of supplying these lights; temporary switchboard, instruments, &c., have been provided, and for a temporary job much care appears to have been bestowed upon it. The principal switchboard is fixed in porter's room, from which the main circuits run to the different floors, the courts, fire brigade and police departments, each in turn being subdivided in the usual way. A 5-light electrolier is fixed in entrance hall, and the main corridor is provided with 3-light electroliers. Three-light clusters, with white glass shades, are hung in the Sessions Court and Police Court; movable standard lamps are also provided in each Court. The clock tower has 24 16-C.P. lamps, which well lights the clock. Lanterns on brackets are fixed at main entrance, each containing 3 16-C.P. lamps, and the entrance to police and fire brigade departments are similarly provided. Drill yard and police cells are also well lighted. The wiring and fittings have been carried out by Benham & Sons, and machinery by Crompton & Co., under the supervision of Mr. B. H. Jenkinson.

Edison & Swan United Electric Light Company.—The Edison & Swan Company have established depôts for the convenience of the trade in Liverpool, Birmingham, Newcastle, Cardiff, Leeds, Hull, Glasgow and Dundee. Stocks will be kept of lamps, fittings, cables, wires, casings, and every accessory for installation work. The company themselves, however, do not in any case contract for installations. After January 1st, orders of £10 and upwards will be delivered free throughout the United Kingdom, either from headquarters or from the depôts.

Scarborough Electric Supply Company, Limited.—The shares forming the recent issue of capital of this company were allotted last week. Actual work will now be commenced at once, and it is anticipated that the light will be turned on in June next, by which time it is expected there will be a considerable demand for current. The alternate current system will be employed with 1,000 volts pressure on the high tension mains. Mr. A. A. Campbell Swinton has been appointed managing director of the company.

Personal.—Major C. B. Waller has been elected to a seat on the board of the London Electric Supply Corporation, Limited, in place of Mr. Arthur F. Wade, resigned, and the thanks of the board have been given to Major Waller for his services as manager and secretary to the Corporation during the past five years.

Mr. R. Stewart Bain has been appointed secretary of the Corporation in combination with his present duties as accountant.

Electric Signals.—The contract for the erection of the electric signals in connection with the Clifton Rocks Railway, has been secured by Messrs. King, Mendham & Co., Western Electrical Works, Bristol, and London. The arrangements to be made include means for signalling from the lower end to the top, the number of passengers to be carried up the railway each journey, replying and starting signals, and telephones.

Quick Work.—On Monday, the 5th inst., Sir Augustus Harris placed an order with Mr. Ronald A. Scott, M.R.I., Acton Hill, to supply and fix one of his 30,000-C.P. projectors on the roof of the Palace Theatre, to be in working order at 7 o'clock in the evening of the 9th inst. Over 200 feet of cable had to be fixed under very awkward circumstances. The installation, however, was completed, and the light running by the time named.

Reid Brothers.—We understand that the extension of the arc lighting of St. Pancras, viz., from Tottenham Court Road to the parish boundary in the Camden Road, has recently been completed by Messrs. Reid Bros., of Wharf Road, City Road. The same firm have also carried out the new trunk telephone line mains, for the General Post Office, from G.P.O. over London Bridge to the London Bridge Railways.

Partnership.—Messrs. Waller & Manville inform us that they are about to enter into partnership with Mr. Joseph Kincaid, M.I.E.E. The arrangement will come into effect on January 1st, 1893, and the business will be carried on under the style of Kincaid, Waller & Manville, at Mr. Kincaid's address, 11, Great George Street, S.W.

Ship Lighting.—The Grangemouth Dockyard Company have just launched from their Grangemouth yard a handsome steamer, named *Ciudad de Reus*, fitted with a complete installation of electric light by Messrs. Scott & Mountain, including side lights and masthead lights, as well as portable hand lights.

Sports by Electric Light.—On Wednesday, last week, the experiment was made at the Whitgift School, Croydon, of lighting one of the fives courts with electricity. The light was put up under the direction of Mr. W. P. Maycock, M.I.E.E., and was a complete success.

Kensington Court Electric Lighting Co., Limited.—A general meeting of the members of this company is to be held on January 19th, to have an account laid before them regarding the manner in which the winding up has been carried out.

The Electric Light in the City.—Among the new work in hand or recently completed we notice that a contract is at present being carried out in the premises of the National Provincial Plate Glass Insurance Company, Limited, Ludgate Chambers, Ludgate Hill, by Messrs. A. Maund & Co., of South Molton Street, W.—Messrs. J. G. Statter & Co., of Victoria Street, S W., have recently completed a contract in the offices of the London and Provincial Bank, Limited, Gresham Street.—Messrs. Laing, Wharton & Down, of New Bond Street, have recently completed work in the Imperial Bank, Gresham Street.—Messrs. Strode & Co., of Osnaburgh Street, N.W., have fitted up Mullins's Hotel, Ironmonger Lane.—The Brush Electrical Engineering Company are engaged at No. 24, Cheapside.—A contract is being carried out at No. 64, Cannon Street, by Messrs. Laing, Wharton & Down, of New Bond Street, W.

Catalogues and Lists.—A catalogue of electric fittings has just been brought out by the Electrical Company, Limited, of Charing Cross Road. A large variety of artistic electric light fittings are illustrated, including fancy wall brackets, pendants, reading lamps in many patterns, table lamps, globes, and other accessories. At the end of the book are full particulars regarding prices of the different articles. We are pleased to recommend this catalogue to the public.

We have also received a number of recent lists from Messrs. Swinburne & Co, of Teddington. They deal principally with condensers, wattmeters, ammeters and voltmeters, galvanometers, and Hedgehog and other patterns of transformers. The lists will be very useful to the firm's customers.

W. T. Henley's Electric Light and Power Company, Limited.—A general meeting of the members of this company is to be held at the offices of Ball, Baker & Co., 1, Gresham Buildings, Basinghall Street, E.C., on January 16th, at 2 o'clock, for the purpose of having an account laid before them showing the manner in which the winding up has been conducted, and the property of the company disposed of, and of hearing any explanation that may be given by the liquidator; and also of determining the manner in which the books, &c., shall be disposed of.

CITY NOTES.

The Morecambe Electric Light and Power Company, Limited.

THE second ordinary meeting of the shareholders of the above company was held at Morecambe on Tuesday, Mr. W. B. Hodgson presiding. A dividend of 5 per cent. on the called-up paid share capital was declared as the result of the first year's working. Important extensions of the service are in progress, and general confidence was expressed as to the soundness and future prospects of the company. The retiring director (Mr. W. C. Farrar) and the auditor (Mr. Duff, of Halifax) were reappointed. Mr. William Morgan (Scarborough), chairman of the company, having resigned in consequence of inability to attend the meetings, the resignation was accepted with regret, and Mr. Twyerould elected director in his place, Mr. W. Hollingworth and Mr. W. Wilson being also added to the directorate.

The British Electric Light Company, Limited.

THE directors' report reads as follows:—

"The directors beg to submit to the shareholders the accounts and balance-sheet, showing the working of the company for the past year. Since the last general meeting the negotiations with the Messrs. Woodhouse & Rawson companies have been completed and settled by payments, as shown in the balance-sheet, and the company is now free from all liabilities and pending law suits in respect to them. The work done by the company during the past year has been chiefly in the direction of installation work, and although up to the present only a small quantity of work is shown by the accounts, yet there are other contracts in hand; and promises of future orders. The company is also making application for a provisional order in the present Session of Parliament for the lighting of the town of Newmarket, which it is anticipated will be a profitable undertaking. The balance to the credit to profit and loss according to the accounts amounts to £915 9s. 6d., out of which the directors recommend a dividend be paid at the rate of 3 per cent. on the 6 per cent. preference shares, and 5 per cent. on the 10 per cent. preference shares, leaving the balance to be carried forward. Mr. H. H. Walters, the director retiring by rotation, and Messrs. James and Edwards, the retiring auditors, being eligible, offer themselves for re-election.

The Electric Construction Corporation, Limited.

THE report of the directors to be submitted to the ordinary general meeting, to be held to-day at Cannon Street Hotel, reads as follows:

"The directors beg to report that notwithstanding many unexpected difficulties which were encountered during the last 12 months, the result of the year's working shows a satisfactory balance to the credit of profit and loss account. The profit for the year is £46,693 11s. 7d., after deducting the expenditure on plant, machinery, and patents, paying the interest on debentures and other loans, and placing a sum of £10,000 to a reserve for bad and doubtful debts. Including the balance of £10,721 19s. 4d. from last year, there is a surplus to be dealt with of £57,415 10s. 11d. The amount of work executed during the last 12 months compares favourably with that of previous years. The contracts with the Liverpool Overhead Railway Company, Limited, and the South Staffordshire Tramways Company, have been nearly completed. The Liverpool overhead line is expected to be in full working order by the end of the year, and the Staffordshire Electric Tramway has already been passed by the Inspector of the Board of Trade, who has expressed himself thoroughly satisfied with the system employed and the work done by this corporation. A very successful system has been carried out for lighting the City of Oxford, and the directors have every reason to believe that these important works will serve to bring large additional contracts to the corporation. During the past year valuable experiments have been carried out at the laboratory of the corporation at Bushbury, in connection with the present methods of producing zinc, chlorine, and alkalies. Mr. Parker considers the results which have been obtained highly encouraging, and a company has been formed for the purpose of commencing the manufacture on a commercial scale, and to demonstrate the value of the patents. Of the preference shares offered for subscription, 2,926 shares were taken up. The capital thus provided has not been sufficient for the purposes of the corporation. With a view, therefore, to improve its general financial position, the directors have consulted the Electric and General Investment Company, Limited. That company has obtained a special report from the auditors, Messrs. Broads, Paterson & Co., and has also caused an examination to be made of the works and plant at Wolverhampton by Messrs. Wheatley Kirk, Price and Goulty, who have reported generally on the manufacturing business of the corporation. As a result of obtaining these reports, and of their own investigation of the affairs of the corporation, the Electric and General Investment Company, Limited, has agreed to issue £100,000 additional capital for the further development of the business, and has guaranteed that the subscriptions shall not be less than one-half of the issue. Such additional capital to be raised by the issue at par of second mortgage debentures of £10 each, bearing interest at 6 per cent. per annum, and redeemable at par by half-yearly drawings over a period of about 15 years, and entitling the holder, by way of bonus, to an income bond of like amount, carrying interest as from the date of the redemption of the corresponding debenture at a rate for each year equal to the dividend declared on the ordinary shares for the preceding year. In order to secure for the shareholders the full benefit of this arrangement, the directors have stipulated with the Electric and General Investment Company, Limited, that the whole of the debentures shall be allotted to the shareholders in proportion to their respective holdings, and a circular carrying out this arrangement is sent herewith. All allotments not taken up by the shareholders or their nominees on or before the 19th inst. will be cancelled. In accordance with the understanding arrived at with the Electric and General Investment Company, Limited, the directors do not propose that any dividend be paid upon the ordinary shares for the past year, but they recommend that the dividend at the rate of 7 per cent. per annum be paid on the preference shares up to September 30th last; that £30,000 be placed to a suspense account, and that the balance of £26,862 1s. 5d. be carried forward. Several retirements from the board have taken place during the year, and as arranged with the Electric and General Investment Company, Limited, the Right. Hon. David Plunket, Q.C., M.P., 12, Mandeville Place, W., and Mr. James W. Barclay, 5, Clarendon Place, Hyde Park, W., have been elected directors, and will take their seats after the general meeting. The directors who retire by rotation are Mr. James Pender and Mr. John B. Verity, who offer themselves for re-election. The directors are determined during the ensuing year to give their special attention to effecting economies in the expenses of administration, and they rely upon the next account showing material retrenchments in this respect, and that no occasions will arise for the exceptional expenditure shown in the accounts for the past year. They are confident, also, that the additional capital proposed to be raised for the purpose of developing the manufacturing business will be the means of largely increasing the net profits. Messrs. Broads, Paterson & Co., the auditors, retire, but offer themselves for re-election.

PROFIT AND LOSS ACCOUNT, from October 1st, 1891, to September 30th, 1892.

DR.	£	s.	d.
To Expenses and cost of production during the year ended September 30th, 1892, at Wolverhampton, including engineering department and laboratory expenses	149,776	13	7
„ Head office expenses, including rents, salaries, income tax, directors' fees, accountancy, printing, stationery and stamp duty, &c.	7,870	3	1
„ Auditors' fee	105	0	0
„ Interest upon debentures and temporary loans ...	8,485	8	0
„ Advertising, law charges and professional fees ...	2,856	6	3
„ Reserve against bad debts, &c.	10,000	0	0
„ Special expenses—Expenses of issues of debentures and preference shares, £7,764 12s. 2d.; allowances on contracts, &c., £9,602 17s.; commission and exhibition expenses, £9,935 0s. 11d.	27,302	10	1
„ Maintenance of and additions to machinery, furniture, &c., £3,125 13s. 8d.; and maintenance of patents and costs of defending same, £3,241 2s. 4d.	6,366	16	0
„ Balance carried to balance-sheet	46,693	11	7
	£259,456	8	7

Cr.	£	s.	d.
By sales and work executed during the year ended September 30th, 1892	175,276	2	2
„ Dividends, transfer fees, rents received and miscellaneous receipts	11,066	14	11
„ Shares received and to be received for licenses granted, patents sold and profits upon formation of subsidiary companies, at par, £123,113 11s. 6d.; less reserved, as per balance sheet, £50,000	73,113	11	6
	£259,456	8	7

BALANCE-SHEET, September 30th, 1892.

	£.	s.	d.	£	s.	d.
To Capital authorised— 62,400 ordinary shares 100 founders' shares 12,500 preference shares. 75,000 of £10 each = £750,000						
of which have been issued—						
49,900 ordinary shares of £10 each	499,000	0	0			
100 founders' shares of £10 „	1,000	0	0			
1,623 pref. shares £10 each fully paid	16,230	0	0			
1,303 pref. shares £10 each, £7 paid	9,121	0	0			
	525,351	0	0			
Less calls in arrear ...	10,501	5	1	514,849	14	11
1,500 first mortgage debentures of £100 each, of which 1,253 have been issued, and remainder deposited as security				125,300	0	0
„ Liabilities:—						
Trade accounts, law charges, &c.	47,244	17	9			
Loans	29,625	0	0			
Interest accrued on debentures	1,493	17	11			
Directors	731	5	0			
Bills payable	34,894	8	4	113,989	9	0
„ Reserve as per last balance-sheet...	25,000	0	0			
Reserve for bad debts, &c. ...	10,000	0	0			
	35,000	0	0			
Less difference between par value of shares sold and the amount realised	6,467	0	0	28,533	0	0
„ Profit and loss account:—						
Balance from last year	10,721	19	4			
Balance of profit and loss as above	46,693	11	7	57,415	10	11
„ Contingent liabilities:— On pending contracts; shares partly paid up, and bills receivable discounted; about £100,000.						
				£840,087	14	10

By Purchase of the works, businesses and patents of Elwell-Parker, Limited, of Wolverhampton, and of the Electrical Power Storage Company, Limited, of London, patent rights, &c., according to last balance-sheet ... £314,847 8 4 (N.B. — Expenditure £3,125 13s. 8d. during the year has been charged to profit and loss, in lieu of depreciation.)	£	s.	d.
„ Shares in subsidiary companies at par, received on capital account, as per previous balance-sheets... 120,000 0 0	434,847	8	4
„ Other shares in subsidiary companies, at par 146,545 0 6			
„ Ditto, to be received, at par ... 95,000 0 0			
241,545 0 6			
Less reserve 50,000 0 0	191,545	0	6
„ Debts due by subsidiary companies	57,572	3	4
„ Book debts	90,961	18	1
„ Stocks at Wolverhampton and Millwall	35,326	9	3
„ Cash at London and General Bank, Limited, in liquidation	3,115	15	9
„ Board of Trade deposit	2,500	0	0
„ Bills receivable in hand	11,591	14	7
„ Cash at bankers	12,627	5	0
	£840,087	14	10

We have examined the above profit and loss account and balance-sheet, with the books, vouchers and accounts of the company, and are of opinion that they are correctly stated: the balance of profit and loss account will not be available for dividend until the shares credited therein have been realised.

BROADS, PATERSON & CO., *Auditors.*

1, Walbrook, London, E.C.,
December 7th, 1892.

The Crompton Electric Supply Company of Australia, Limited.—The third annual general meeting of the shareholders of the Crompton Electric Supply Company of Australia, Limited, is to be held at the registered offices of the company, Mansion House Buildings, on Monday, the 19th day of December inst., at 3 o'clock p.m. This meeting is called in compliance with the articles of association, but as the directors have not yet received the audited statement of accounts from Sydney to May 31st last, the end of the company's financial year, it will be impossible to lay them before the meeting, and therefore a resolution will be proposed adjourning the meeting to await the arrival of the accounts. Mr. W. Trotter, J.P., chairman of the Australian committee of the company, is at present in London, but is leaving again for Sydney at the end of the month. He will attend the above meeting and make a verbal report to the shareholders on the position and prospects of the company.

African Transcontinental Telegraph Company, Limited.—A prospectus has been issued of the African Transcontinental Telegraph Company, Limited. The capital is £400,000, divided into 400,000 shares of £1 each. The company is proposed to be formed to construct a line of telegraphs in Africa from the present terminus of the British South Africa Company's lines at Salisbury, Mashonaland, *via* Lake Nyassa, Lake Tanganyika, and Uganda, to the terminus of the Anglo-Egyptian telegraph lines at Wady Halfa, Egypt (approximate distance 3,000 miles). It is proposed to start immediately with the construction of the line to the British Protectorate of Nyassaland, and from thence to Uganda. The capital will only be called up as the opportunities for the work require, and, as the construction to Uganda is estimated to cost about £140,000, the directors will proceed to allotment if sufficient subscriptions for this section are obtained.

Electric Construction Corporation, Limited. — Accompanying the favourable report of the directors of the Electric Construction for the year ended September 30th, 1892, we have received a prospectus of some debentures which the Construction Corporation have authorised the Electric and General Investment Company to issue to the existing shareholders according to their present holding. The issue is of £100,000 second mortgage debentures of £10 each to bearer, bearing interest at 4 per cent. per annum. These debentures are redeemable at par by half-yearly drawings over a period of about 15 years, and will rank next after the existing first mortgage debentures of £150,000 as a charge upon the whole undertaking and property of the corporation, present and future, and are secured by trust deed made between the Electric Construction Corporation, Limited, and the Electric and General Investment Company, Limited, the trustees.

Elmore's Foreign and Colonial Patent Copper Depositing.—The accounts for the financial year of the company ended December 31st last show a balance at that date of £132,203. The directors, in their report, state that they cannot at this time recommend the payment of a dividend; but they hope to be able, in the course of 1893, to make a distribution to the priority shareholders, leaving a handsome amount in hand for distribution among the founders. At the present moment, taking the company's assets at par value, and after setting aside £5 per share and a fourth of the balance of the priority shares, or an extra £2 15s. per share, there remains an amount equal to £13 per share for the founders. We shall give the report and accounts fully in our next issue.

Brighton and Hove Electric Light Company, Limited.—This company announces that it is prepared to receive applications for £7,500 first mortgage debentures at par, being the balance unissued of a total issue of £15,000 of such debentures. The debentures are of £100 each, carrying interest at the rate of 6 per cent. per annum, and are convertible into ordinary shares, at the option of the holder, at any time on one month's notice. The business of the company was established in 1882, and the company itself was incorporated in 1885.

Stock Exchange Announcements.—Applications have been made to the Stock Exchange Committee to grant a quotation to Eastern Telegraph Company, Limited, further issue of £94,100 4 per cent. mortgage debenture stock. Elmore's Patent Copper Depositing Company, Limited, additional shares Nos. 82,441 to 91,240.

The Eastern Extension, Australasia, and China Telegraph Company, Limited.—The directors have declared an interim dividend for the quarter ended September 30th last of 2s. 6d. per share, tax free, payable on January 16th next.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending December 11th, 1892, amounted to £932; corresponding month, 1891, £815; increase £117; total receipts to date, 1892, £19,739; corresponding period, 1891, £17,798; increase £1,941.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 9th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,865.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.	Closing Quotation December 8th.	Closing Quotation, December 15th.	Business done during week ending December 15th, 1892. Highest.	Lowest.
195,100*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	100—103	100 —103	...	...
1,247,720*l*	Anglo-American Telegraph, Limited	Stock	50 — 51	49½— 50½	50	49½
2,876,140*l*	Do. do. 6 p. c. Preferred	Stock	91 — 92	91 — 92	91⅝	91⅛
2,876,140*l*	Do. do. Deferred	Stock	11 — 11½	10⅞— 11¼xd	11	10 13/16
130,000	Brazilian Submarine Telegraph, Limited	10	10⅝— 11¼	10⅝— 11¼	11¼	10⅝
34,600*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	106 —110	106 —110	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	3 — 3¼	3 — 3¼	3 3/16	3 1/16
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2⅛— 2⅜	2⅛— 2⅜	2⅜	2⅛
40,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	3 — 4	3 — 4	...	...
600,000*l*	City and South London Railway	Stock	3 — 4	35 — 38	...	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	10¼— 10⅜	10¼— 10⅜	10 5/16	10 5/16
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	5 — 5⅛	5 — 5⅛	5⅛	5⅛
8',716,000	Commercial Cable, Capital Stock	$100	178 —182	175 —185 xd	182½	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ..	14/-	5/16— 5/16	3/16— 5/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	5 — 5⅛	5 — 5⅛	...	...
16,000	Cuba Telegraph, Limited	10	11½ — 12⅛	11⅛— 12⅛	11⅞	...
6,000	Do. do. 10 p. c. Preference	10	17½ — 18⅛	17⅛— 18⅛	17⅞	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2⅛— 3⅛	2⅛— 3⅛	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅛— 11⅜	11 — 11⅛	11⅜	11 3/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜— 15	14⅜— 14⅞	14⅛	14⅛
70,000	Do. 6 p. c. Preference	10	15⅜— 16⅛	15⅜— 16⅛	16⅛	16
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	...	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	109 —112	109 —112	111	109⅛
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅜— 15	14⅜— 14⅞	15	14⅜
70,600*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	104 —107	104 —107	...	...
250,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	104 —107	104 —107	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	109 —112	109 —112	...	...
122,400*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	104 —107	104 —107	...	...
163,700*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	104 —107	104 —107	...	...
300,000*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	103 —106	103 —106	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	3 — 3½	2½— 3	3	1⅛
19,900	*Electricity Supply Co. of Spain, Nos. 191 to 20,000	5	.. ..	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	⅜— ⅝	⅜— ⅝	⅝	...
82,395	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	1½— 1½	¾— 1	1⅛	¾
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	¾— 1	⅜— ⅝	¾	⅝
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	2 — 3	2 — 3	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅜— 10	9⅜— 10	9⅞	9⅜
180,042	Do. do. 6 p. c. Preference	10	14⅛— 15⅛	14⅛— 15⅛	15⅛	15
150,000	Great Northern Tel. Company of Copenhagen	10	19½— 19⅝	19½— 19⅝	19½	...
210,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	104 —107	104 —107	...	...
12,134*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½— 5½	4½— 5½	...	...
9,600*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	8 — 9	8 — 9	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21 — 22	21 — 22	22	21⅝
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	43 — 45	44 — 46	45⅝	45
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	2½— 3½	2½— 3½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	6 — 7	6 — 7	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	3 7/16— 3 9/16	3 7/16— 3 9/16	...	...
10,000	Do. do. fully paid	5	5 1/16— 5 3/16	5 1/16— 5 3/16	5 1/16	4⅞
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	4 — 6	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	107 —110	108 —111	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	6½— 7	6½— 7	6⅞	6⅝
50,000*l*	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	101 —104 xd	101 —104	103	...
454,747	National Telephone, Limited, Nos. 1. to 438,984	5	4⅞— 5⅛	4⅞— 5 xd	5 1/16	4⅞
15,000	Do. 6 p. c. Cum., 1st Preference	10	14½— 15½	14½— 15½xd	14 13/16	...
15,000	Do. 6. p. c. Cum. 2nd Preference	10	13¾— 14½	13¾— 14½	14 5/16	14
90,950	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	3½— 3¾	4 — 4½xd	4 1/16	3 5/16
726,477*l*	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	112 —114	112 —114	113⅝	113
48,800*l*	New Telephone, Limited, Nos. 25,901 to 74,700 ... (£2 paid)	10	4⅜— 4⅝	4⅜— 5	4⅞	4⅜
6,318	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	5 — 6	5 — 6	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	3/16— 5/16	1/16— 1/8	...	...
11,802	Reuter's Limited	8	7½— 8½	7½— 8½	...	...
18,680	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	7¾— 8¼	7¾— 8¼	8¼	7⅞
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	8¼— 8⅜	8¼— 8⅜	...	...
3,381	Submarine Cables Trust	Cert.	116 —120	116 —120	119	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	3 — 3½ xd	3 — 3½	3¼	3 1/16
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	45 — 47	47	45½
150,000*l*	Do do. do. 5 p. c. Bonds, red. 1894	100	103 —106	103 —106	...	...
58,000	United River Plate Telephone, Limited	5	2½— 3	2½— 3	...	...
146,370*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	90 — 100	90 — 100	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	6½— 7½	6½— 7½	...	...
260,900*l*	Do. do. do. 5 p. c. Debentures	100	100 —103	100 —103	...	...
30,000	West Coast of America Telegraph, Limited	10	2½— 3½	2½— 3½	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	103 —107	104 —108	...	...
64,242	Western and Brazilian Telegraph, Limited	15	7 — 7½	7 — 7½	7⅜	7⅛
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5½— 5⅝	5½— 5⅝	5⅝	...
33,129	Do. do. do. 5 p. c. Deferred	7½	1½— 1⅝	1½— 1⅝	1⅝	1½
184,100*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	106 —109	106 —109	...	...
230,100*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	106 —109	106 —109	...	...
88,321	West India and Panama Telegraph, Limited	10	1½— 1⅝	1½— 1⅝	1⅝	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10 — 10⅛	10 — 10⅛	10⅛	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	8 — 9	8 — 9	...	...
80,000*l*	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	104 —107	105 —108	...	...
$1,536,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
171,000*l*	Do. do. 6 p. c. Sterling Bonds	100	100 —103	100 —103	..	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	5⅜— 6¼	5½— 6	5 7/16	5⅜

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange. BANK RATE OF DISCOUNT.—3 per cent. (October 20th, 1892).

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Blackpool Electric Tramway Company, Limited, £10 (£6½ paid 7½—7⅝.—Electric and General Investment, shares of £5 (£1 paid), 2⅜—3⅛.—Founders' shares, 200—225.—Electric Construction Corporation, 6 per cent. Debentures, 95—98.—Elmore Foreign and Colonial Copper, Founders shares, 6⅜—7⅛.—European Sims-Edison Torpedo Company, shares £20 (fully paid), 20—20½.—Founders' shares, 10—20.—Halifax and Bermuda Cable 4½ per cent. bonds 80—90.—House to House Company (£5 paid) 2⅛—3⅛.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5—5⅛, 1st Preference Cumulative 6 per cent., £5 (fully paid), 5⅛—5⅜.—Liverpool Electric Supply Shares of £5 (fully paid), 5 1/16—5 3/16.—Manchester, Edison and Swan Company, £9 (£1 paid), ⅛—¼.—Queen Anne's Mansions Lighting and Heating, Deferred shares of £10 (fully paid), 10—⅛.—Do. 4½ per cent. preference shares of £10 (fully paid), 10—⅛.—Do. Debentures, 103—¼.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), ⅛—⅜.—£5 Preference (fully paid), 2⅛—3.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

EXPERIMENTAL RESEARCHES ON ALTERNATE CURRENT TRANSFORMERS. By J. A. FLEMING, M.A., D.Sc., F.R.S., Member. (Read November 24th.)

(*Continued from page* 696.)

In fig. 3 is shown a curve representing the values of $W_1 - W_2$ for the Ferranti 5 H.P. transformer, taken from the results in Tables V. and VI. The secondary output of the transformer in watts is set off on the horizontal line, and the vertical ordinates of the upper curve are the corresponding values of the "total lost watts," or total power losses in the transformer at these various loads. The lower curve is the curve of total copper ($c^2 r$) losses, taking both primary and secondary together. The difference between the ordinates of the upper and lower curves represents the power lost in the transformer in iron losses and eddy current copper losses, if any. It is seen that the upper curve keeps roughly parallel to the lower curve, and that, therefore, as far as these observations go, there is no indication that the core losses get less as the output increases; on the other hand, they seem to get slightly greater. It is much more convenient and instructive to plot out in this way a "total loss curve" for the transformer than to plot an efficiency curve, for if an accompanying $c^2 r$ curve is drawn, it shows us at once what is the magnitude of the total eddy current and hysteresis losses to be accounted for. The values of $W_1 - W_2$ for the Swinburne "Hedgehog" given in Tables VII. and VIII. are found when plotted to lie so irregularly that an exact determination of the total loss curve by these tables is impossible. The power-factor of the "Hedgehog," even at full load, is still small, and we were not satisfied with the general nature of the results given at all loads by the three-voltmeter method for this transformer. In the case of the Ferranti 5 H.P. transformer (1885 type), the determinations of the power taken up at no secondary load were fairly consistent, being as follows for seven observations: 516, 516, 504, 540, 538, 509, 516, all taken at a primary pressure of 2,400 volts and a frequency of 82 to 85. The mean of these values is 520 watts. At a frequency of 87 and a primary voltage rather above 2,400, we found for the same quantity the values 563, 565, 568, 552, 566, 561 watts, in six different experiments. The mean of all, corresponding to a frequency of about 83, is probably close to 540 watts, as given in Table I.

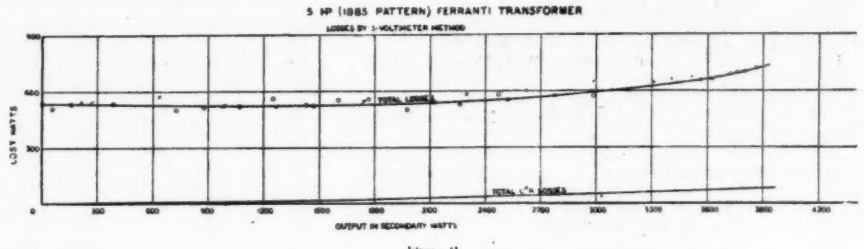


FIG. 3

III.—EXPERIMENTS WITH THE THREE-AMMETER METHOD OF MEASURING ALTERNATING CURRENT POWER.

10. We next directed our attention to that modification of the voltmeter method suggested by the writer, and which involves current measurements instead of pressure. Theoretically, this method requires three ammeters, A_1, A_2, A_3, arranged in connection with the transformer under test, as shown in fig. 4. The third ammeter, A_3, measures the current flowing through an inductionless resistance put across between a pair of high tension mains kept at the potential required for the primary circuit of the transformer to be tested. Two other ammeters, A_2 and A_1, measure the current before and behind the point of take-off of this resistance. In putting this method into practice, we found it necessary in the first place to scheme some simple method of regulating the P.D. at the terminals of the transformer under test. This was accomplished as follows:—A 10 H.P. transformer had its primary, or fine wire, circuit inserted in series with the primary current of the transformer under test. The secondary, or thick wire, circuit of the 10 H.P. transformer was closed through a variable resistance consisting of 15 to 20 plates of battery carbon 3 inches square and a quarter of an inch in thickness, pressed together more or less by a screw clamp. By suitably compressing these plates we were able to regulate with great nicety the secondary current of the 10 H.P. transformer, and hence to adjust the resultant impedance of the primary circuit of the 10 H.P. transformer. The volts at the terminals of the transformer under test could then be kept perfectly constant, irrespective of slight variations due to the dynamo. This adjustment was made by placing one of the calibrated Swinburne voltmeters across the terminals of the transformer under test, and always adjusting the carbon rheostat until the P.D. of these terminals was 2,400 volts. As a non-inductive resistance we employed a series of 50 C.P. incandescent lamps. We then found that, working under these conditions, we could dispense with the third ammeter, A_3, and make one measurement once for all of the current taken by this series of lamps at 2,400 volts. We found that this current remained constant over great ranges of time. The experiments consisted, therefore, in measuring the primary current of the transformer under test by two ammeters in series, from the junction point of which was led off the constant current for a series of lamps. The P.D. at the ends of this series of lamps was kept perfectly constant at 2,400 volts, as shown by the voltmeter, v (fig. 4). We found considerable difficulty in getting two suitable ammeters for the positions A_1 and A_2 which would agree with one another with the requisite accuracy, and finally we reduced the method to the use of a single ammeter, as follows:—An ammeter was put in the primary circuit of the transformer under test, and the P.D. at the terminals of this transformer was kept constant at 2,400 volts. A series of incandescence lamps (generally 24 100-volt 16 C.P. lamps) was joined across the primary mains, and two readings of the ammeter taken—a first when the row of lamps was between the ammeter and transformer, and a second when the ammeter was between the lamps and transformer. An independent determination was made of the current taken by the lamps. These changes of position of the ammeter were made by mercury cup connections, so as to avoid at any time actually breaking the primary circuit. As an ammeter we employed first an Ayrton and Perry twisted strip ammeter, and finally a Siemens dynamometer of low resistance. It will be easily seen that this single-ammeter method possesses all the advantages, whatever they are, of the three-ammeter method, and is much simpler to work.

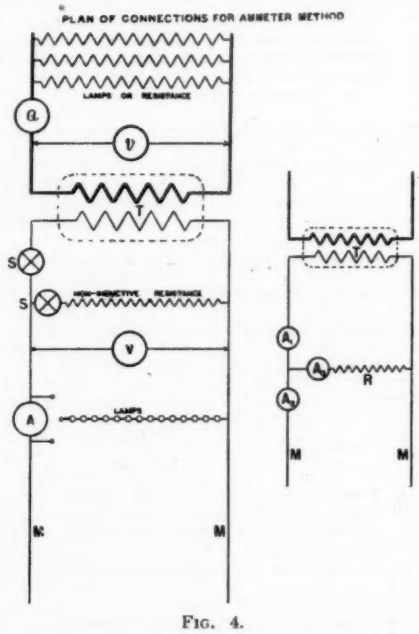


FIG. 4.

If A_1 is the reading of the ammeter when it is between the transformer and the lamps, and A_2 the reading when the lamps are between it and the transformer, and A_3 is the value of the current through the lamps, and v the P.D. at the terminals of the series of lamps, it is easy to show that the power, w, taken up in the transformer is given by the expression,

$$w = \frac{v}{2 A_3}\left\{A_2^2 - A_1^2 - A_3^2\right\}.$$

In order to test the method, we applied it to measure the power taken up in the practically inductionless resistance coil (No. 1 standard). The resistance of this coil when traversed by about a quarter of an ampere is 9,590 ohms. The value of the currents were in this case $A_2 = 0{\cdot}88$, $A_1 = 0{\cdot}24$, $A_3 = 0{\cdot}65$, and $v = 2{,}400$.

Hence the power taken up, as calculated from the three-ammeter observations, is 544 watts; whilst the power absorbed, as reckoned from the known value of the resistance and current going through it, is 552 watts. Applying it to measure the power absorbed in two transformers already tested by the voltmeter method—viz., the 5 H.P. Ferranti and the 6,500-watt Westinghouse—when on open secondary circuit, the number obtained by the ammeter method was 580 watts for the Ferranti and 97 watts for the Westinghouse. These values are rather higher than the mean values obtained by the volt-

meter method, viz., 540 and 93·5 watts, and, in spite of its greater simplicity, the one-ammeter method did not give very satisfactory results, even on closed magnetic circuit transformers. It was next applied to test the Swinburne 3,000-watt "Hedgehog" when on open circuit. It was fonnd here that, as in the case of the three-voltmeter method, still greater difficulty was experienced in getting experimental results which agreed numerically well together.

It is not worth while to give all the details of the observations made on the 3,000-watt "Hedgehog" transformer by this one-ammeter method. Suffice it to say that, using sometimes an Ayrton and Perry twisted strip ammeter carefully calibrated, and sometimes a Siemens dynamometer, both adapted for measuring from 0·02 to 4 ampères, we obtained such figures as these for the power in watts taken up at no load in the transformer, viz.: 116, 116, 183, 153, 100, 164, 176, 110, 124, 200, 113, 71, 79, 79, 47, 108, 87, 75, 103, 88, 100, 80, 88, in 23 different determinations. Curious to say, the arithmetic mean of all these values is 111, or almost exactly the same as the mean value obtained from the 30 observations by the three-voltmeter method; the greatest deviations from the mean being about the same percentage. The conclusions arrived at with respect to this ammeter method is, that ordinary commercial ammeters do not enable us to determine the currents with anything like the accuracy necessary when we are operating on open magnetic circuit transformers at no load. It would certainly be necessary to be able to read currents of magnitudes from 0·25 to 5 ampères to the third decimal place, and that is not in general a practicable matter by commercial instruments. After many further trials of this method on different transformers, we were obliged to come to the same conclusions with respect to it as those forced upon us in regard to the voltmeter methods, viz., that it is an unsuitable one for transformers of small power-factor, but that with great care and a suitable ammeter it may be made to yield fairly good results for closed magnetic circuit transformers of large power factor. It may be noted in passing that in applying this ammeter method in any case the most favourable condition for accuracy is when the current through the transformer primary is equal to the current through the non-inductive shunt. Hence the shunt resistance should be decreased as the load on the secondary of the transformer is increased if we desire to obtain a uniform possibility of accuracy in the measurements of the power supplied.

The above statement can be proved by following a similar line of reasoning to that pursued by, with regard to the three-voltmeter method, Prof. Ayrton and Dr. Sumpner, in their paper on "The Measurement of the Power given by any Electric Current to any Circuit."* For the expressions for the power in terms of the currents or of the potential differences are similar in mathematical form.

IV.—Experiments with the Dynamometer-Wattmeter Method of Measuring Alternating-Current Power.

11. Dissatisfied on the whole with the practical results and difficulties of the voltmeter and ammeter methods, attention was next turned to the employment of the dynamometer wattmeter as an instrument for the measurement of the power given to the primary circuit of transformers. There is no need to recapitulate well-known facts about the use of such an instrument for this purpose. It is well understood that a wattmeter or dynamometer with independent series and shunt coils can be used for this purpose provided that the shunt circuit has a practically zero time constant, and the only difficulty which presents itself in passing an opinion on the suitability of any

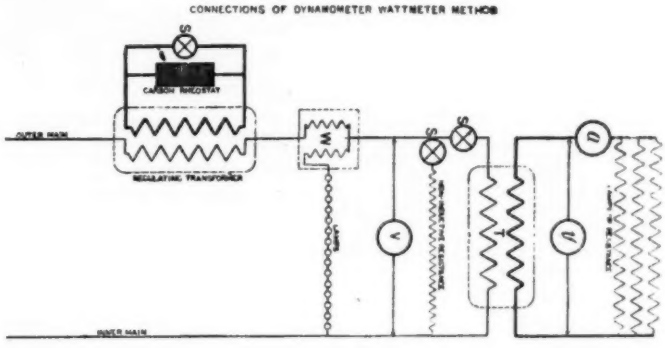


FIG. 5.

TABLE IX.—*Ferranti Transformer* (1885 *pattern*).

No. 747. Power, 5 H.P. Secondary volts, 100.
Frequency used, 81·6 periods per second.
Average final temperature of transformer = 212° F.
Volts on primary circuit (v_1) = 2,400 (kept constant).
Primary circuit resistance = 12·50 ohms at 212° F.
Secondary circuit resistance = 0·0252 ohm at 212° F.

Secondary circuit.			Primary circuit.				Total power taken up in transformer.		Efficiency, $\frac{w_2}{w_1}$ in per cents.
					Watts.				
Volts.	Amperes.	Watts w_2.	Volts.	Amperes.	By dynamometer wattmeter w_1.	By Swinburne wattmeter.	By dynamometer wattmeter, $w_1 - w_2$.	By Swinburne wattmeter.	
100·9	0	0	2,400	0·332	549	511	549	511	0
101·0	1·00	101	,,	0·360	665	606	564	505	15·2
101·0	2·94	297	,,	0·43	853	803	556	506	34·8
100·9	4·81	485	,,	0·504	1,035	994	550	509	46·8
100·8	7·28	734	,,	0·598	1,272	1,221	538	487	57·7
100·8	9·16	923	,,	0·673	1,461	1,423	538	500	63·2
100·7	11·18	1,126	,,	0·747	1,691	1,639	565	513	66·6
100·5	13·00	1,307	,,	0·820	1,890	—	583	—	69·1
100·3	14·93	1,498	,,	0·893	2,068	—	570	—	72·4
100·2	17·89	1,793	,,	1·015	2,372	—	579	—	75·6
100·0	20·78	2,078	,,	1·132	2,677	—	599	—	77·6
100·0	23·62	2,362	,,	1·260	2,960	—	598	—	79·9
99·9	26·61	2,653	,,	1·382	3,232	—	574	—	82·2
99·8	29·33	2,927	,,	1·500	3,538	—	611	—	82·8
99·8	31·37	3,131	,,	1·584	3,724	—	593	—	84·0
99·5	33·17	3,300	,,	1·661	3,926	—	626	—	84·1
99·2	34·93	3,466	,,	1,732	4,091	—	625	—	84·8
99·1	36·93	3,661	,,	1·816	4,298	—	637	—	85·2
99·1	38·78	3,844	,,	1·890	4,480	—	636	—	85·9
101	0	0	,,	—	549	506	549	506	0

TABLE X.—5-H.P. (1885 *pattern*) *Ferranti Transformer*.

Primary volts = 2,400 (kept constant).
Secondary volts at no load = 100·9

Primary current, I_1.	Secondary current. I_2.	$\frac{I_2}{24}$	Copper losses in watts.			Total secondary drop in volts.	Primary watts.		Power-factor. $\frac{w_1}{w_1'}$
			Primary, $I_1^2 \times 12·6$.	Secondary $I_2^2 \times 0·0252$	Total.		Real, w_1.*	Apparent, w_1'.	
0·329	0	0	1·3	0	1	0	538	790	0·68
0·403	2·10	0·087	2·1	0·1	2	0	759	966	0·79
0·474	3·99	0·166	2·8	0·4	3	0·8	839	1,136	0·74
0·554	6·33	0·263	3·8	1·1	4	0·9	1,205	1,329	0·90
0·686	9·80	0·408	5·9	2·4	8	1·0	1,503	1,648	0·91
0·795	12·65	0·527	7·9	4·1	12	0·9	1,786	1,907	0·94
0·888	14·70	0·612	9·8	5·5	15	1·1	1,989	2,130	0·93
1·000	17·44	0·726	12·5	7·7	20	1·2	2,283	2,400	0·95
1·155	21·26	0·886	16·7	11·4	28	1·2	2,658	2,774	0·96
1·236	23·07	0·961	19·2	13·5	33	1·3	2,880	2,966	0·97
1·323	25·38	1·057	21·9	16·3	38	1·6	3,075	3,179	0·97
1·368	26·46	1·102	23·4	17·7	41	1·8	3,226	3,280	0·99
1·430	28·00	1·166	25·6	19·8	45	2·0	3,344	3,433	0·97
1·493	29·53	1·230	28·0	22·0	50	1·9	3,434	3,586	0·96
1·517	30·13	1·255	28·7	22·9	52	1·9	3,630	3,640	0·99
1·559	31·11	1·298	30·4	23·5	54	2·0	3,680	3,738	0·99
1·601	32·06	1·336	32·2	26·0	58	2·0	3,775	3,846	0·98
1·659	33·41	1·393	34·4	28·2	63	1·9	3,953	3,979	0·99
1·695	34·35	1·431	36·0	29·7	66	1·9	4,066	4,063	1·00
1·743	35·50	1·480	38·1	31·8	70	2·0	4,152	4,187	1·00
1·763	36·00	1·500	38·9	32·6	72	2·1	4,218	4,240	1·00
1·796	36·61	1·528	40·5	33·9	74	2·1	4,275	4,304	0·99
1·821	37·09	1·545	41·6	34·8	76	2·2	4,406	4,366	1·00
1·839	37·58	1·567	42·3	35·6	78	2·3	4,414	4,404	1·00
1·861	38·11	1·588	43·4	36·6	80	2·4	4,453	4,461	1·00
1·875	38·57	1·608	44·0	37·5	82	2·4	4,503	4,500	1·00
1·900	39·19	1·633	45·2	38·7	84	2·4	4,580	4,555	1·00

* These primary watts are determined from a different set of observations to those recorded in Table IX., but substantially agree with them.

* See *Proc. Roy. Soc.*, London, Vol., xlix, March, 1891, p. 434.

particular two-circuit dynamometer for this purpose is that of knowing whether the shunt circuit really *is* practically so far free from sensible inductance or capacity as to make this the case—and this, as our experiments show, must not be taken for granted without investigation. Two wattmeter dynamometers were provided. The first consisted of a Siemens dynamometer of the usual pattern intended to be used as an ammeter for currents from 0·2 to 4 ampères. The fixed coil consisted of a few dozen or so turns of wire, and the movable coil of four turns. We arranged the connections so that it could be used as a wattmeter; the fixed coil being the series coil, and the movable coil of four turns being put in series with 24 100-volt 50-C.P. incandescent, or also with two rows of 24 16-C.P. lamps arranged in parallel, and this arranged as a shunt circuit. Contrary to the usual practice, we had then a wattmeter in which the shunt circuit carried volts, and kept at that value by a regulating transformer with carbon resistance on the secondary circuit (see fig. 5); and from these measurements the power taken up in the resistance was known. It was 5,357 watts. The dynamometer wattmeter was then arranged so as to measure the known power being absorbed by this resistance, and the constant of the wattmeter was thus determined. A torsion of 175° of the dynamometer head was found to be required when the resistance was absorbing the above power. This constant was frequently determined. The value was close to 30·6 watts per division of the scale. It will be seen, therefore, that we were employing a wattmeter which, although it absorbed considerable power in its own shunt circuit, had a range of measurement from 12,000 watts down to about 10 or 12 as a minimum visible.

We found it essential to standardise the wattmeter on the largest

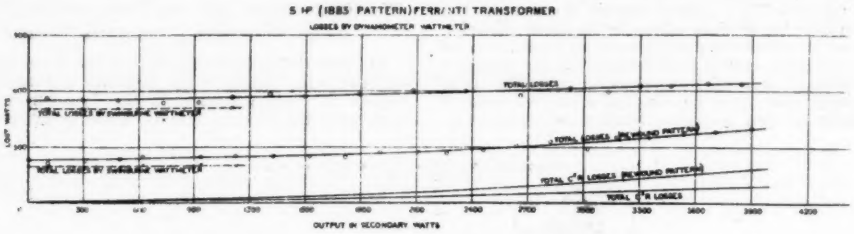

5 HP (1885 PATTERN) FERRANTI TRANSFORMER
LOSSES BY DYNAMOMETER WATTMETER
TOTAL LOSSES
TOTAL LOSSES (REWOUND PATTERN)
TOTAL C²R LOSSES (REWOUND PATTERN)
TOTAL C²R LOSSES
OUTPUT IN SECONDARY WATTS

FIG. 6

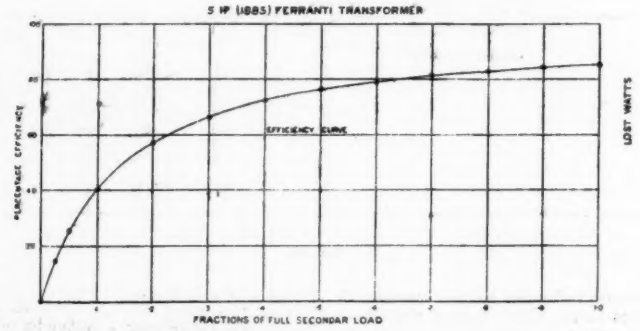


FIG. 7.

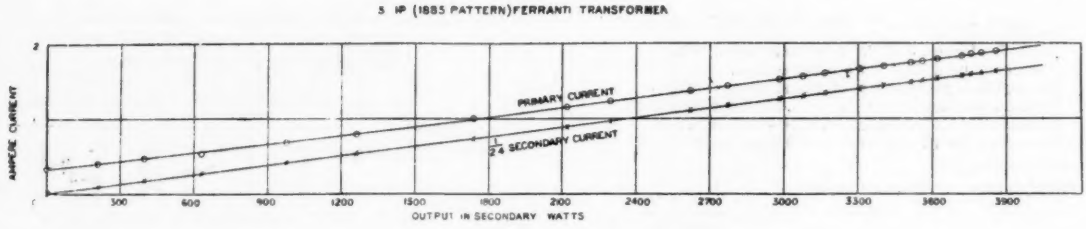


FIG. 8.

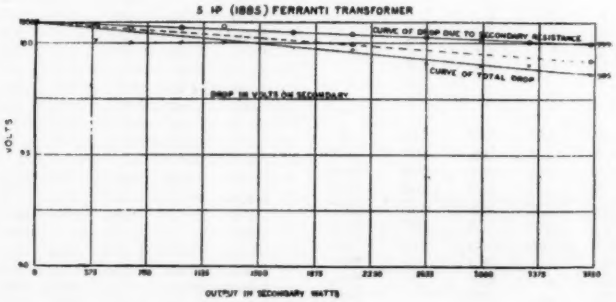

5 HP (1885) FERRANTI TRANSFORMER
CURVE OF DROP DUE TO SECONDARY RESISTANCE
CURVE OF TOTAL DROP
DROP IN VOLTS ON SECONDARY
VOLTS
OUTPUT IN SECONDARY WATTS

FIG. 9.

[These four figures are typical of the manner in which all the other transformers were treated.—EDS. ELEC. REV.]

the larger current. This circuit was traversed by a current of from 1·8 to 2·94 ampères when placed across 2,400-volt mains, according to the group of lamps used.

This dynamometer wattmeter had, then, a shunt circuit consisting of the 24 series of lamp filaments plus the four turns of wire on its movable coil. It had, therefore, a very small inductance. This wattmeter was calibrated by applying it to measure the known power taken up in our standard resistance. The six coils of our No. 1 resistance, each consisting of about 1,600 ohms, were arranged, two in series and three in parallel, across 2,400-volt mains. The current through these resistances was measured by a Kelvin deciampère balance, and found to be 2·230 ampères; the P.D. between the mains was measured by the Swinburne voltmeter, and found to be 2,400 power-absorbing arrangement possible, so as to get the greatest possible wattmeter scale reading on a known power-absorption in determining the instrumental constant. For if a small power reading was taken, then any error in the scale reading was multiplied up in getting the watts corresponding to a larger scale reading taken from a value of the constant, and sensible errors introduced.

In addition to this instrument, Mr. Swinburne provided two of his own non-inductive wattmeters. In this last instrument the shunt circuit consisted of a small bobbin of a good many (probably a hundred or more) turns of fine wire, having a resistance of about 300 ohms. In series with this externally, and forming part of the wattmeter shunt circuit, were two doubly wound wire resistances in brass boxes; having a total

resistance of about 100,000 ohms, assumed to be practically non-inductive. Provided with these wattmeters, we proceeded to make a series of tests on various transformers of the power absorbed when the transformer was doing secondary work of various loads. The results are embodied in the series of tables given. In each case the Siemens dynamometer, called hereafter the "dynamometer wattmeter," was standardised on the inductionless resistance when absorbing about 7 H.P., and then, having obtained

TABLE XI.—*Ferranti Transformer* (1885 *pattern, re-wound*).

No. 539. Power, 5 H.P. Secondary volts, 100.
Frequency used, 81·6 periods per second.
Average final temperature of transformer, 150° F.
Volts on primary circuit (v_1) = 2,400 (kept constant).
Primary circuit resistance = 29·80 ohms at 150° F.
Secondary circuit resistance = 0·057 ohm at 150° F.

Secondary circuit.			Primary circuit.		Watts.		Total power taken up in transformer.		Efficiency, $\frac{w_2}{w_1}$, in per cents.
Volts.	Amperes.	Watts, w_2.	Volts.	Amperes.	By dynamometer wattmeter, w_1.	By Swinburne wattmeter.	By dynamometer wattmeter, $w_1 - w_2$.	By Swinburne wattmeter.	
102·7	0	0	2,400	0·11	235	225	235	225	0
102·7	1·02	105	„	0·14	318	305	213	200	33·0
102·4	2·99	306	„	0·22	534	501	228	195	57·3
102·1	4·86	496	„	0·29	732	682	236	186	67·8
102·1	6·08	621	„	0·34	870	817	249	196	71·5
101·9	9·16	934	„	0·47	1,182	1,139	248	205	79·0
101·7	11·09	1,125	„	0·555	1,376	1,334	251	209	81·9
101·5	13·07	1,327	„	0·638	1,578	1,527	251	200	84·1
101·2	15·03	1,521	„	0·713	1,771	—	250	—	86·0
101·0	16·97	1,714	„	0·799	1,960	—	246	—	87·5
100·8	18·89	1,904	„	0·880	2,176	—	272	—	87·6
100·6	20·97	2,109	„	0·960	2,380	—	271	—	88·7
100·4	22·56	2,265	„	1·036	2,531	—	266	—	89·6
100·0	24·60	2,460	„	1·112	2,746	—	286	—	89·6
99·7	26·46	2,638	„	1·192	2,946	—	308	—	89·6
99·5	28·35	2,821	„	1·265	3,152	—	331	—	89·6
99·3	30·40	3,019	„	1·350	3,308	—	289	—	91·2
99·1	32 06	3,177	„	1·429	3,529	—	352	—	90·0
99·0	33·88	3,354	„	1·504	3,703	—	349	—	90·6
98·8	35·78	3,535	„	1·582	3,904	—	369	—	90·6
98·6	37·58	3,706	„	1·669	4,088	—	382	—	90·8
98·4	39·65	3,902	„	1·741	4,301	—	399	—	90·7
102·9	0	0	„	0·08	229	209	229	209	0

TABLE XII.—*5-H.P.* (1885 *pattern, re-wound*) *Ferranti Transformer.*

Primary volts = 2,400 (kept constant).
Secondary volts at no load = 102·7.

Primary current, I_1.	Secondary current, I_2.	$\frac{I_2}{24}$.	Copper losses in watts.			Total secondary drop in volts.	Primary watts.		Power-factor, $\frac{w_1}{W_1}$.
			Primary, $I_1^2 \times 29·8$.	Secondary, $I_2^2 \times 0·057$.	Total.		Real, w_1.	Apparent W_1.	
0·11	0	0	0	0	0	0	235	264	0·98
0·14	1·02	0·043	0·6	0·2	1	0	318	336	0·95
0·22	2·99	0·166	1·4	0·5	2	0·3	534	528	1·01
0·29	4·86	0·202	2·5	1·3	4	0·6	732	696	1·05
0·34	6·08	0·254	3·5	2·1	6	0·6	870	816	1·06
0·47	9·16	0·382	6·6	5·9	12	0·8	1,182	1,128	1·05
0·555	11·09	0·496	9·2	7·0	16	1·0	1,376	1,332	1·03
0·638	13·07	0·544	12·2	9·7	22	1·2	1,578	1,531	1·02
0·713	15·03	0·626	15·2	12·9	28	1·5	1,771	1,711	1·03
0·799	16·97	0·707	19·0	16·4	35	1·7	1,960	1,917	1·02
0·880	18·89	0·787	23·1	20·3	43	1·9	2,176	2,112	1·03
0·960	20·97	0·874	27·4	25·0	52	2·1	2,380	2,304	1·03
1·036	22·56	0·940	32·0	28·2	61	2·3	2,531	2,486	1·02
1·112	24·60	1·025	37·0	34·5	72	2·7	2,746	2,669	1·03
1·192	26·46	1·102	42·3	39·5	82	3·0	2,946	2,861	1·03
1·265	28·35	1·181	47·7	45·5	93	3·2	3,152	3,026	1·04
1·350	30·40	1·267	54·2	52·6	107	3·4	3,308	3,240	1·02
1·429	32·06	1·338	61·0	58·9	120	3·6	3,529	3,429	1·03
1·504	33·88	1·412	67·5	65·2	133	3·7	3,703	3,609	1·03
1·582	35·78	1·491	74·5	73·0	148	3·9	3,904	3;797	1·05
1·669	37·58	1·566	83·0	80·5	164	4·1	4,088	4,006	1·02
1·741	39·65	1·652	90·0	89·5	180	4·3	4,301	4,178	1·03

the constant, its readings were taken when placed on the primary circuit of the transformer. The column headed "Power taken up by Swinburne Wattmeter," records the observations made with the first wattmeter he sent having an outer case of brass.

In Table IX. are given the figures of observation for the 5-H.P. (1885 type, old form) Ferranti transformer. The tranformer had gradually increasing loads of lamps put upon its secondary circuit, and whilst the power, w_1, supplied to the primary was measured by the dynamometer wattmeter, that given up by the secondary, w_2,

TABLE XIII.—*Westinghouse Transformer.*

Power, 6,500 watts. Secondary volts, 100.
Frequency used, 82·5 periods per second.
Average final temperature of transformer, 96° F.
Volts on primary circuit (v_1) = 2,400 (kept constant).
Primary circuit resistance = 5·95 ohms at 96° F.
Secondary circuit resistance = 0·0108 ohm at 96° F.

Secondary circuit.			Primary circuit.		Watts.		Total power taken up in transformer.		Efficiency, $\frac{w_2}{w_1}$, in per cents.
Volts.	Amperes.	Watts w_2.	Volts.	Amperes.	By dynamometer wattmeter, w_1.	By Swinburne wattmeter.	By dynamometer wattmeter, $w_1 - w_2$.	By Swinburne wattmeter.	
101·0	0	0	2,400	0·050	95	—	95	—	0
100·9	1·00	101	„	0·100	205	—	104	—	49·3
100·8	1·98	200	„	0·140	306	—	106	—	65·4
100·8	2·94	296	„	0·180	401	—	105	—	73·7
100·7	3·87	390	„	0·218	493	—	103	—	79·1
100·7	4·79	482	„	0·250	597	—	115	—	80·7
100·7	8·00	806	„	0·382	920	—	114	—	87·6
100·4	10·15	1,019	„	0·472	1,139	—	120	—	89·5
100·3	13·07	1,311	„	0·580	1,440	—	129	—	91·1
100·1	18·00	1,802	„	0·800	1,930	—	128	—	93·4
100·1	19·90	1,992	„	0·880	2,118	—	126	—	94·1
100·0	21·93	2,193	„	0·960	2,330	—	127	—	94·1
100·0	24·74	2,474	„	1·080	2,609	—	135	—	94·8
100·0	29·66	2,966	„	1·285	3,096	—	130	—	95·8
99·8	37·20	3,713	„	1·610	3,870	—	157	—	96·0
99·5	42·00	4,179	„	1·810	4,324	—	145	—	96·7
99·3	46·65	4,633	„	2 002	4,792	—	150	—	96·9
99·2	50·40	5,000	„	2·160	5,174	—	174	—	96·7
99·0	52·16	5,164	„	2·240	5,422	—	258	—	95·3
98·9	55·60	5,499	„	2·383	5,702	—	203	—	96·1
98·8	57 68	5,700	„	2·478	5,885	—	185	—	96·9
98 9	59·32	5,867	„	2·550	6,041	—	174	—	97·3
98·7	61·32	6,053	„	2·633	6,271	—	218	—	96·7
98·8	62·16	6,142	„	2·672	6,344	—	202	—	96·8
98·7	63·00	6,218	„	2·700	6,426	—	208	—	96·8
98·7	64·00	6,317	„	2·750	6,522	—	205	—	96·9
98·6	64·74	6,384	„	2·775	6,598	—	214	—	96·9

TABLE XIV.—*Westinghouse Transformer.*

Primary volts, 2,400 (kept constant).
Secondary volts at no load = 101·0.

Primary current, I_1.	Secondary current, I_2.	$\frac{I_2}{24}$.	Copper losses in watts.			Total secondary drop in volts.	Primary watts.		Power-factor, $\frac{w_1}{W_1}$.
			Primary, $I_1^2 \times 5·95$.	Secondary, $I_2^2 \times 0·0108$.	Total.		Real, w_1.	Apparent, W_1.	
0·050	0	0	0	0	0	0	95	120	0·79
0·100	1·00	0·042	0	0	0	0·1	205	240	0·85
0·140	1 98	0·083	0·1	0	0	0·2	306	336	0·91
0·180	2·94	0·122	0·2	0·1	0	0·2	401	432	0·93
0·218	3·87	0·161	0·3	0·2	0	0·3	493	523	0·94
0·250	4·79	0·199	0·4	0·2	1	0·3	597	600	0·99
0·382	8·00	0·333	0·9	0·7	2	0·3	920	917	1·00
0·472	10·15	0·423	1·3	1·1	2	0·6	1,139	1,133	1·00
0·580	13·07	0·545	2·0	1·8	4	0·7	1,440	1,392	1·03
0·800	18·00	0·750	3·8	3·5	7	0·9	1,930	1,920	1·00
0·880	19·90	0·830	4·6	4·3	9	0·9	2,118	2,112	1·00
0·960	21·93	0·914	5·5	5·2	11	1·0	2,330	2,304	1·01
1·080	24·74	1·031	6·9	6·6	14	1·0	2,609	2,592	1·01
1·285	29·66	1·238	9·8	9·5	19	1·0	3,096	3,084	1·00
1·610	37·20	1·550	15·4	14·9	30	1·2	3,870	3,864	1·00
1·810	42 00	1·750	19·5	19·0	39	1·5	4,324	4,344	0·99
2·002	46·65	1·945	23·9	23·5	47	1·7	4,792	4,805	1·00
2·160	50·40	2·100	23·7	27·5	55	1·8	5,174	5,184	1·00
2·240	52·16	2·171	29·8	29·5	59	2·0	5,422	5,376	1·01
2·383	55·60	2·320	33·9	33·5	67	2·1	5,702	5,719	1·00
2·478	57·68	2·404	36·5	36·0	73	2·2	5,885	5,947	0·99
2·550	59·32	2·474	38·7	38·1	77	2·1	6,041	6,120	0·99
2·633	61·32	2·560	41·2	40·6	82	2·3	6,271	6,319	0·99
2·672	62·16	2·594	42·5	41·8	84	2·2	6,344	6,413	0·99
2·700	63·00	2·623	43·3	42·9	86	2·3	6,426	6,480	0·99
2·750	64·00	2·665	45·0	44·2	89	2·3	6,522	6,600	0·99
2·775	64·74	2·700	45·8	45·3	91	2·4	6,598	6,660	1·00

was measured by a Kelvin balance and electrostatic voltmeter placed on the secondary circuit. We measured also the primary current value in ampères corresponding to each definite load on the secondary

circuit. We obtained, therefore, for every transformer, the volts, or P.D. across both terminals, the ampère current, and the watt output of the secondary circuit, and at the same time the ampère current and power absorbed in watts by the primary circuit; and hence the difference between w_1 and w_2, or the power lost in the transformer, is also known for each secondary load. Finally, also, the ratio of w_2 to w_1 in percentages can be calculated, and gives us the efficiency. In all these experiments the P.D. on the primary terminals was kept carefully constant at 2,400 volts, and the constant of the primary wattmeter checked at the beginning and end of each series of observations.

A series of tests of this kind was made on each one of the following 10 transformers: A Ferranti 5-H.P. (1885 type), a Ferranti 5-H.P. (after having had the primary and secondary circuits both replaced by others of double the length), two 15-H.P. (1892 type) Ferranti, a 20-H.P. (1892 type) Ferranti, a Westinghouse 6,500-watt (the same transformer used by Dr. Hopkinson in his recent tests), a Mordey-Brush 6,000-watt, a Thomson-Houston 4,500 watt, a Kapp 4,000 watt, and a Swinburne 3,000 watt "Hedgehog." For each transformer was determined the currents and terminal potential differences corresponding to the various stages of secondary load from no load up to the full nominal output of the transformer, and at the same time the power, w_1, given to the transformer primary circuit, and the power, w_2, taken off from the secondary circuit. The "total lost watts," $w_1 - w_2$, and the efficiency, or ratio, $\frac{w_2}{w_1}$, corresponding to each secondary load were also calculated. From the known or measured value of the resistances of the copper circuits (taken when the transformer was warm) and the measured currents we could calculate the copper losses ($C^2 R$ losses) in both circuits, separately and together, to the nearest integer, omitting fractions of a watt in most cases; and from the primary volts and current we obtained the value of the "apparent watts" given to the transformer at each stage; and from the "apparent" and "true" watts given to the primary circuit we could deduce the power-factor corresponding to any secondary output. The values of the secondary terminal P.D., or volts, gave us also the "total secondary drop" at each load, and from the resistances and currents could be found the "copper drop," or volts lost by resistance. The observations and calculations for each of the 10 transformers tested are given in full in Tables IX. to XXIX., inclusive, which sufficiently explain themselves.

12. The results of these numerous observations are set out graphically, and thus represented to the eye, in a series of diagrams. For each transformer four diagrams have been prepared.

The first shows the "total lost watts" curve, or $w_1 - w_2$, plotted as a curve in terms of the corresponding secondary output, w_2; and on the same diagram is given a curve showing the total copper losses ($C^2 R$) in the transformer in both circuits together. Hence the difference of the ordinates of these two curves gives the value of the losses other than those due to ohmic resistance in the transformer. The second diagram shows the value of the two currents, primary and secondary, plotted in terms of the secondary output. Since all the closed magnetic circuit transformers tested had a transformation ratio and windings in the ratio of 24 to 1, the primary current and $\frac{1}{24}$th part of the secondary current are plotted together on the same scale. The third diagram gives the efficiency curve. The efficiencies in per cents., corresponding to decimal fractions of the full secondary output, are calculated from the "total loss" curve and then drawn. Hence they are all comparable, and we can see at a glance the percentage efficiency corresponding to loads of $\frac{1}{10}$th, $\frac{2}{10}$ths, &c., of the full secondary load. The fourth curve is the "secondary drop" curve, and gives the "total observed drop," the "drop" due to secondary and to primary resistance, and the surplus or "leakage drop," due to leakage of induction, all plotted in terms of the secondary output. The efficiency values are tabulated in Table XXX. for the different fractions of full load for all the transformers.

13. It is desirable to make one or two remarks about each transformer, and draw some general conclusions.

Ferranti Transformer, 1885 *type*, 5 *H.P.* (Tables IX. and X. figs. 6, 7, 8, 9.)

It is obvious that this transformer is, in comparison with modern ones of the same size, very wasteful of energy in transformation. But we must bear in mind that in 1885 little or none of our present knowledge about iron core energy losses existed, and it is not to be wondered at that its design is imperfect, according to modern views. The immense core loss of 549 watts (540 by three-voltmeter method) makes it possess a low efficiency at all loads and gives it a flat efficiency curve. Its small copper losses, however, make it remarkably good in regulation, it having only 2·4 per cent. of total secondary drop. It is hardly necessary to say that Mr. Ferranti's present type of transformer is a vast improvement on these, and holds its own with the best now made.

Ferranti Transformer, 1885 (*re-wound*). (Tables XI. and XII.)

The effect of doubling the length of both the primary and secondary circuit is shown in the curves of this transformer. The total internal losses are halved, but the copper losses and "secondary drop" about doubled.

Westinghouse Transformer, 6,500 *watt*. (Tables XIII. and XIV.)

This transformer was one of the pair tested by Dr. J. Hopkinson by his elegant differential method. His results are recorded in the *Electrician* of June 24th and July 1st, 1892. Employing a method depending upon the graphic description of the instantaneous curves of current and electromotive force, Dr. Hopkinson deduced the power lost in the transformer at no load, quarter, half, and full load. Hence the corresponding efficiencies. The same quantities were given me independently as determined by the manufacturers from tests made at Pittsburgh. These are here collected with my own results for comparison. Dr. Hopkinson's results are placed in the column marked H, those of the manufacturers in column P, and my own in column F; and it will be seen that we all substantially agree in the values of the quantities measured.

Quantities measured.	P.	H.	F.
Watts lost at no load	91	114	98
Watts lost at half load	—	149	141
Watts lost at full load	—	236	209
Secondary drop at full load ...	2%	2·2%	2·4%
Efficiency at half load	96·4%	96%	96%
Efficiency at full load	97%	96·9%	96·9%
Total copper losses ($C^2 R$) at full load, in watts	104	—	93

It is clear, therefore, that there is no serious disagreement between us, and that this transformer is a very excellent instrument. Its maximum efficiency is just upon 97 per cent., and its efficiecy at $\frac{1}{10}$th of full load is nearly 85 per cent.

The loss in power at no load is by my figures 1·46 per cent. (by Dr. Hopkinson's 1·75 per cent.) of the full secondary output. The core of this transformer is made of a high quality of pure steel, the plates being slightly oxidised to insulate them for eddy currents.

(*To be continued.*)

NEW PATENTS—1892.

21,693. "An improved electrical meter and recorder." P. FEYS and J. LORWA. Dated November 28th.

21,696. "Improvements in electric smelting of aluminous and other refractory ores or compounds." T. L. WILLSON. Dated November 28th.

21,701. "Improvements in the reduction or treatment of refractory metallic compounds by electric smelting." T. L. WILLSON. Dated November 28th.

21,703. "Electric apparatus for illuminating the sights of fire-arms in the dark." G. G. DI GIOVANNI. Dated November 28th.

21,750. "Improvements in means or apparatus for use in type writing, or type writing inter-communication with the aid of electricity." A. D. NEAL and H. F. EATON. Dated November 29th. (*Complete.*)

21,782. "Improvements in electrical resistance coils." SIEMENS BROS. & Co., LIMITED, and J. NEBEL. Dated November 29th.

21,794. "Improvements in the manufacture of electrodes for ozonisers." E. ANDREOLI. Dated November 29th. (*Complete.*)

21,803. "Improvements in electric transformers." C. E. L. BROWN. Dated November 29th.

21,807. "Improvements in or appertaining to the manufacture of caustic soda and chlorine." S. Z. DE FERRANTI and J. H. NOAD. Dated November 29th.

21,811. "Improvements in multiphase alternating current motors without separate excitation." C. E. L. BROWN. Dated November 29th.

21,830. "Improvements in apparatus connected with flexible electrical conductors and in electrical connections therefor applicable for use in mines." C. W. ATKINSON and THE ELECTRICAL COAL CUTTING CONTRACT CORPORATION, LIMITED. Dated November 29th. (*Complete.*)

21,874. "Improvements in electric light and other pendants." H. L. T. LYON. Dated November 30th.

21,906. "An electric alarm of danger from fire or water." A. LIEDCKE and P. JACOBI. Dated November 30th.

21,919. "Improvements in the method of making electrical connections and disposition of circuits carrying induced currents." C. OLIVETTI. Dated November 30th.

21,940. "Improvements in or relating to multiple telephones." L. P. MOREAU and C. J. A. MUNIER. Dated November 30th. (Date applied for under Patent Act, 1883, Sec. 103, May 28th, 1892, being date of application in France.)

21,951. "Improvements in the manufacture of porous earthenware pottery articles for electrolytic purposes." W. ALLEN. Dated December 1st.

22,001. "Improvement in incandescent electric lamps." (Duplex filament.) L. HENDLE and E. R. CUMMINS. Dated December 1st.

22,034. "Improvements in and in connection with electricity meters." G. BINSWANGER. Dated December 1st.

22,035. "Improvements in electrical switches and other fittings." G. BINSWANGER. Dated December 1st.

22,038. "Improvements in and relating to stands for incandescent electric lamps." J. CATHREIN. Dated December 1st.

22,061. "Improvements in or in connection with an electric motive power system." W. L. SPENCE and D. STEWART & Co., LIMITED. Dated December 2nd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1891.

The Price of all Specifications (old and new) is now 8d. each.

2,040. "Improvements in switches for secondary batteries or accumulators." H. MULLER. Dated February 4th. Consists of two series of contact pieces, which are connected to the single cells of the battery, alternating with metallic insulated pieces, so as to form two guides for the sliding contact lever. Parallel to the same are arranged two conducting rods which are connected by a resistance. 4 claims.

2,471. "Improvements in cells for electrical or storage batteries and the manufacture of lead for the the same." T. W. BUSH and M. DOUBLEDAY. Dated February 11th. The inventors manufacture "hydrolised" lead by pouring molten lead into water or any other fluid at suitable temperatures necessary for the particular purpose of producing spongy, granulated, honeycombed lead, or shot. One element may consist of any of the aforesaid preparations of lead contained in a porous pot, which is placed within another vessel and then surrounded by the same or any other of the aforesaid preparations of lead for the other element. Another method is to divide any vessel of suitable form into compartments, by nonconducting porous divisions, filling each compartment with the preparation of lead. 3 claims.

4,740. "Improvements in and connected with electrical signalling for railways." G. F. ATTREE. Dated March 17th. A secondary battery or other source of electricity is arranged preferably under the signalman's box, this is in connection with an uncovered electrical lead or conductor placed between the lines, each lead is preferred to be laid in duplicate, and is carried into the signalman's box and connected to a lamp, and to a switch and converter. The engine is fitted with red and green lamps or a lamp with movable red and green shades. The front of the engine is fitted with contact makers, consisting of disc wheels arranged to bear upon the leads between the lines when the engine meets them, these contact makers being electrically connected with the lamps or other alarm apparatus on the engine. The signalman operates the current by the switch or convertor to show either the red or green lamp on the engine, and to ring a bell or blow the whistle when the engine meets the lead, then the signalman is electrically warned of the same. 2 claims.

6,660. "Improvements in the method of distribution of electrical energy and in apparatus incidental thereto." S. Z. DE FERRANTI. Dated April 17th. The inventor establishes in every district one, or more distributing stations, located at a convenient distance apart, and instals therein large-sized converters connected in parallel or banked as specified in Patent No. 15,251 in the year 1885, of a total capacity equal to the demand of the district, together with a suitable reserve set; the converters being arranged so that the high tension current of 2,400 volts, 10,000 volts, or other suitable voltage on arriving from the generating station should be transformed down to 100 volts, 200 volts, or other convenient pressure. 25 claims.

7,075. "Improvements in incandescent electric lamp holders, ceiling roses, and other like fittings. F. H. ROYCE. Dated April 24th. On the wire or wires entering electric fittings, such as incandescent lamp holders, ceiling roses, connection sockets, &c., the inventor causes them to be tightly clamped between a washer or cover and inner portion of the fitting, with the object of taking any strain put upon such wires off the terminal connections, and he preferably effects this by first passing the wire or wires through a hole in the cover or washer, and then bending them at right angles so that they lie upon the face of an inner part of the fitting, the cover or washer then being screwed up or tightened by any means, effectually clamps them and holds them rigidly in position. 1 claim.

CORRESPONDENCE.

High-Pressure Steam Generators.

Mr. Thwaite does not altogether approve of my criticism of his boiler. Without taking his reply *seriatim*, I would first note his desire to show me a photograph of a Lancashire boiler to open my eyes. Evidently he concludes I know nothing of the Lancashire boiler, so I will simply state that I have spent some thousands of hours in them, and have had probably a far wider and far more close and intimate experience of steam boilers generally than has fallen to the lot of Mr. Thwaite.

As regards stresses in boilers, the chief of the stresses in Lancashire boilers are due to the flat end, and this is a concession to appearances. If made hemispherical, or even dished, there would be at once abolished both stresses and staying. Then, as to explosions, let me advise Mr. Thwaite to make a little enquiry into the explosions of water-tube boilers before singing so loudly of the explosions of Lancashire or Cornish boilers, and let him name any Lancashire boiler explosion for which good cause cannot be shown, if not actual pre-knowledge of the danger. One of the worst multiple explosions arose from the hanging of the boilers by their manhole mouthpieces; others have come from dome weakness, but none has arisen with a modern made boiler, reasonably cared for. Water-tube boilers are only safe with good water, and they lack steadiness, and fall short in evaporative efficiency, and as to foreign engineers adopting them, we know that as regards Mr. Thwaite's progressive American, the water-tube boiler was made for smokeless coal, and is one of the very worst possible types for bituminous fuel; and on this point I would inform Mr. Thwaite that my knowledge and experience of the subject of combustion and smoke are fully equal to his own, and acquired probably in a far more practical manner. His Bunsen burner suggestion is worthless. The purified and intimate mixture used in the laboratory behaves very differently from the raw and crude distillates from a boiler furnace.

Smoke is produced in vertical boilers for the same reason that it is produced in the ordinary water-tube boiler. We don't want large steam storage on a boiler. The real requirement is large water storage—hot water, too.

Grooving of end plates and angle irons is not due to unequal expansion, but to alternate expansion consequent on unequal temperature of furnace. It may be reduced by mechanical firing, but it is no evidence of any stress which can be avoided, though it was more so when the end plate staying was made rigid, as in years gone by was customary. Electrolytic action, so often trotted out, is, if present, due to acidity, and there will be very little of this if the water is kept alkaline.

Take Manchester water, and use a little soda, and where do you find either corrosion or scale? I contend that there were no fundamental disadvantages in the form of the Lancashire boiler in 1866, so am in a sort of accord here with Mr. Thwaite. The faults of 1866 were in details rather than in principles. What can be wrong in a boiler shell of circular cross-section, or in a similar flue-tube?

American engineers don't use water-tube boilers by any means exclusively; they use plain flat ended return-tube cylindrical boilers of far simpler build than either Lancashire or water-tube boilers, and they are, Mr. Thwaite to the contrary, very conservative in their habits, and by no means so devoid of follow-my-leaderism as some suppose, *e.g.*, their sticking to the bar frame in locomotives years after we have discarded it; their slow appreciation of the fire-brick arch, and many other instances could be named. We will not quarrel over German. I prefer English, and would doubt the claim made for the German language, which has fewer genuine words than our own, and has to build up words to get its technical terms. As regards literary merit, Mr. Thwaite is more curious than edifying. Should I happen to write in a magazine the same month as the Premier, then we should get a nice little equation: $P : x\,P :: C : \theta$, and C, your reviewer would come out on those lines far and away before θ. On this score, I can only compliment Mr. Thwaite on the high opinion which must have been formed by the editor of the leading monthly of the *matter* of his article, if it chanced to be in the same florid Teutonic as the boiler essay. As to the boilers Mr. Thwaite proposes, one only appears to have a refractory furnace, whilst the objectionable kink in the firebox of the small boiler is quite as bad as the flat end of a cylinder boiler as regards liability to grooving. I need not here go into the question much further. So far as regard samples from exploded boilers, perhaps Mr. Thwaite has already seen the museums at No. 9, Mount Street, and 22, St. Ann's Square, Manchester. He can there see relics of both Lancashire and water-tube boilers which have gone up, and he can study the practical outcome of a recognition of the causes which lead up to both explosions and the faults of grooving he names, and I can promise him, should he thoroughly examine as many hundred or thousand boilers as I have done, he will as clearly recognise my objections to the types he advocates as I do myself, and he will be better disposed to acknowledge that the boiler of to-day in its design, construction and setting, bears no resemblance, in the eye of an expert, to the boiler of thirty years ago. True, the only differences are in a wider sweep of a pair of compasses by the designer, or similar changes, but far smaller changes have often made or marred a valuable invention.

The Reviewer.

A Curious Coincidence (?)

Can any of your readers inform me whether the following is a coincidence only; if so, it is a most remarkable one:—

In 1857 a patent specification, numbered "929," was filed by David Joy, relating to steam engines, *the arrangement of their valves*, &c. In 1879 a patent specification, also by David Joy, relating to *valve gear*, was filed, the number of this specification is also "929." As the numbers are given to the specifications by the Patent Office authorities in order as the specifications are received, and are not (presumably) manipulated by them to produce apparent coincidences, the fact seems a remarkable one.

A Constant Reader.

London, *December 13th.*

The Price of Electric Supply.

The interesting letter of Mr. Bromley Holmes in your last issue shows very clearly the disadvantages of baseing a sliding scale of charges upon the maximum demanded supply when this is taken to mean simultaneous supply to all the lamps, &c., fitted on the consumer's premises, and it does not appear that the use of a maximum current indicator in connection with each consumer's meter, as suggested by Prof. Kennedy, would quite meet all the difficulties.

We may suppose that, by using the heating effect of the current to operate the indicator, or by the use of a dashpot, the indicator movement might be made so slow as to prevent the record from being seriously affected by a momentary increase in the current, such as would be required to blow a fuse. Otherwise an accidental short circuit might considerably increase the price per unit for that unfortunate consumer for a whole quarter, and thus lead to undue friction with, if not to sparking at, the collector. It may be said, however, that the ultimate effect would be desirable, inasmuch as it would tend to the more general adoption of such arrangements as would almost abolish the chances of accidental short circuits on any but the smallest branches, *i.e.*, at the lamp-holders, &c.

We may further suppose that the indicator would be reset at the proper time only, and after its reading had been duly noted by a trustworthy inspector. Even then this system of charging does not always tend to produce the effect to be desired alike in the interests of the supply company and of its consumers, viz., a large load factor.

For instance, churches, requiring supply on Sundays only, would have to pay the highest rate, but it would be to the interest of the supply company that the rate should be reduced on Sundays in order to develop demand when a large part of the plant would remain idle if the higher price prevailed.

Similarly, during the two summer quarters, business places and many other customers would have to pay the higher rate. The demand would thus be repressed in the summer time, when in the interests of the supply company it should be developed by reducing the charge. Shop windows would probably be kept alight if supplied at a lower rate after business hours. Motors, also, would be more extensively used for intermittent work, and purposes requiring supply for only one or two hours daily, if the supply were charged at a low rate, always excepting during the time of heaviest demand for lighting purposes. This would frequently result in arrangements being made to avoid taking supply just at this time, thus increasing the load factor.

From the concluding clause of Mr. Holmes's letter, it might be supposed that in matters which affect the system of charging there is no essential difference between the supply of gas or water, and the supply of electricity. It may therefore be well to refer to the differences. For convenience, let that part of the total annual cost which is made up of interest on capital, depreciation, and such other expenses as vary very little with the duration of the demand, be called the fixed expenses.

In the supply of gas and water, owing to the cheapness of storage, and the large variation which is allowable in the pressure at the consumers' terminals, a comparatively small increase in the fixed expenses enables the produce of the machinery to be delivered to consumers when required, at about ten times the rate which it is produced at the works.

In the case of electricity, owing to the lack of any efficient means of modifying the pressure such as would be equivalent to the reducing valve commonly used with branch gas-pipes and burners, it is necessary to maintain the pressure within very narrow limits at the consumers' terminals. For reasons well understood, the fixed expenses are proportional not to the greatest consumption during a period of, say, two days, as in the cases of gas and water, but to the maximum rate of supply provided for, although this rate may be demanded for less than one hour in the year.

Consequently the problem of charges for supply is essentially more complicated in the case of electricity than in the case of gas and water, and the central stations which are able to vary their rates of charge in such a way that their customers reap the benefit of fitting in their demands to produce a large load factor, will, other things being equal, pay better dividends, and develop a larger and more varied demand than the stations with a fixed scale of charges.

W. B. Sisling.

The Dangers of Electric Lighting.

From a letter printed in your issue of 9th inst., it would seem that in spite of my letter of May 31st, 1892, efforts have apparently been made to connect Mr. Musgrave Heaphy with the fire at Scott's Oyster Bar, which occurred in May last. I would like to repeat what I said in evidence, namely, that while discovering evidences of the wiring having been carried out in such a way as to call for adverse comment, I found *no direct evidence of the fire having been caused by the electric lighting arrangements.*

I gave my reasons for my views as regards the method of wiring and quoted Mr. Musgrave *as an authority on the subject* in support of my opinion and not as implying in any way, directly or indirectly, that Mr. Heaphy could, or should, be held responsible for the condition of the wiring.

As a matter of fact, I learnt, in the course of my inquiries prior to submitting my report to the Coroner, that only a portion of the risk was held by the Phœnix Fire Office, that it had quite recently been transferred, and that the office was ignorant of the fact that the premises were electrically lighted.

However vexatious such incidents may be to Mr. Heaphy personally, there is no doubt that the fact of his being appealed to whenever anything goes wrong with the wiring of a house in London, is an unintentional tribute to the extent of his fame as an authority on these matters.

Ed. C. de Segundo.

A Strange Incident.

I wish to call attention to a strange incident that I experienced a few days ago when experimenting with a (200-ampére) 80-volt Manchester dynamo.

The machine was running with the pilot lamp and voltmeter in circuit only, at 80 volts, with one brush down on either side of the commutator. On lifting the top brush two seconds after stopping the engine, the pilot lamp became *quite incandescent*, and the voltmeter registered about 120 volts, but it was only for an instant. I should feel obliged for information, if you or any of your readers have had a similar experience at any time, and also what is the probable cause of this peculiarity.

I have an opinion myself on the subject, and have also seen the opinion of a gentleman high in the scientific world, but I cannot agree with him at present. Trusting you will insert this in your valuable paper.

Mystified.

Re Fire at London Stereoscopic Company's, Regent Street.

Mr. Heaphy, in his letter of December 6th in your last issue, has taken an exaggerated and erroneous view of my letter to your contemporary. I made the remarks on what I believed to be reliable authority, but as I am not permitted to publish the names of my informants I am bound to withdraw the remarks and express regret for publishing them.

J. D. F. Andrews.